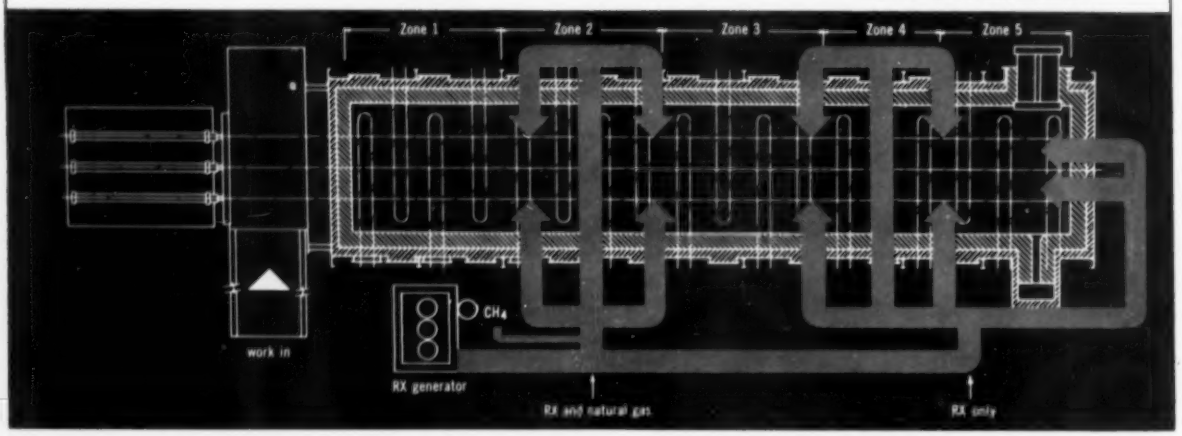
Metal Progress

April 1906

April 1956



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Metal Progress

Volume 69, No. 4

April 1956

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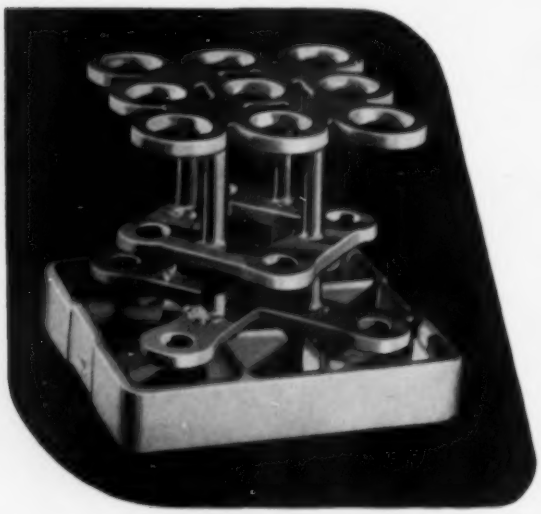

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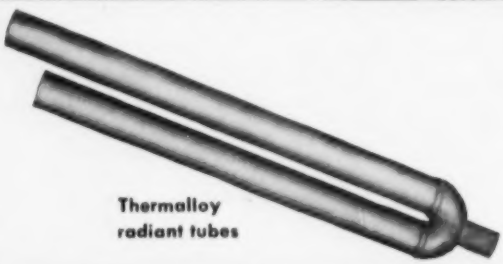
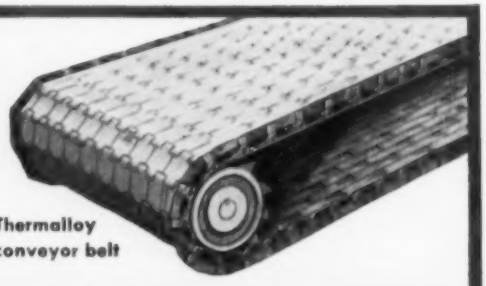


Thermalloy radiant tubes



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As I was saying...

IT SEEMS to be but yesterday that President Art Focke and I were in the Washington office of Paul Hoffman, director of the ECA, where we presented to him a plan for the A.S.M. to sponsor a World Metallurgical Congress in Detroit in '51 during the National Metal Congress and Exposition. The proposal to have the metal scientists of the free countries of the world come to America at the same time, to participate in planned plant inspections, and to exchange technical and scientific knowledge, secured the instant approval of Director Hoffman. He stated it was an excellent plan, one that had not been tried before, but should accomplish what he most wished – a closer and happier relationship among the technical men of all countries.

We left the conference very happy with the knowledge of his enthusiastic okay and the splendid support of his able staff.

Everybody went to work, and literally hundreds of ASMers guided the First W.M.C., with 550 overseas conferees in attendance, to such an outstanding conclusion that the prestige of the Society was enhanced to the highest limits.

Since '51, the A.S.M. received and accepted ('55) an invitation to participate with the leading metal technical societies of Europe (England, Germany, France, Belgium, Sweden, Italy and Spain) in a European Metallurgical Congress. This proved to be a most memorable event for the 250 attending.

So here goes again – the announcements and invitations for the Second W.M.C. have been mailed, going first to the ambassadors of all the free countries of the world having any interest in metals, then to all American ambassadors and counsellors in overseas countries, and to technical societies in overseas countries. Some 7000 announcements and letters have been dispatched. The information booklet is now being translated into German, French and Spanish for intensive distribution to those interested.

A.S.M.'s Past-President, Dr. Zay Jeffries, has been appointed by the Board as Director-General of the 2nd W.M.C., having served so splendidly in the same position in the first Congress.

Conferees will meet in New York City on Saturday, Oct. 19, 1957, each having selected one of the nine groups according to his predominant interest. Each of these groups will then proceed on a guided tour to important cities and plants for two weeks. All groups will arrive in Chicago on Saturday, Nov. 2. The last seven days of each tour will be spent at the National Metal Congress and Exposition and the 2nd W.M.C., which will convene from Nov. 2 through 8, 1957.

Again members of the A.S.M. will be appointed to participate in the Congress as counterparts to the overseas conferees. Many will be called upon, as they were in the first Congress, and will again find that activity one of the most stimulating and satisfying experiences of a lifetime since it will cement friendship and good will that will be everlasting.

Much more later! So long for now!

Cordially,

Bill

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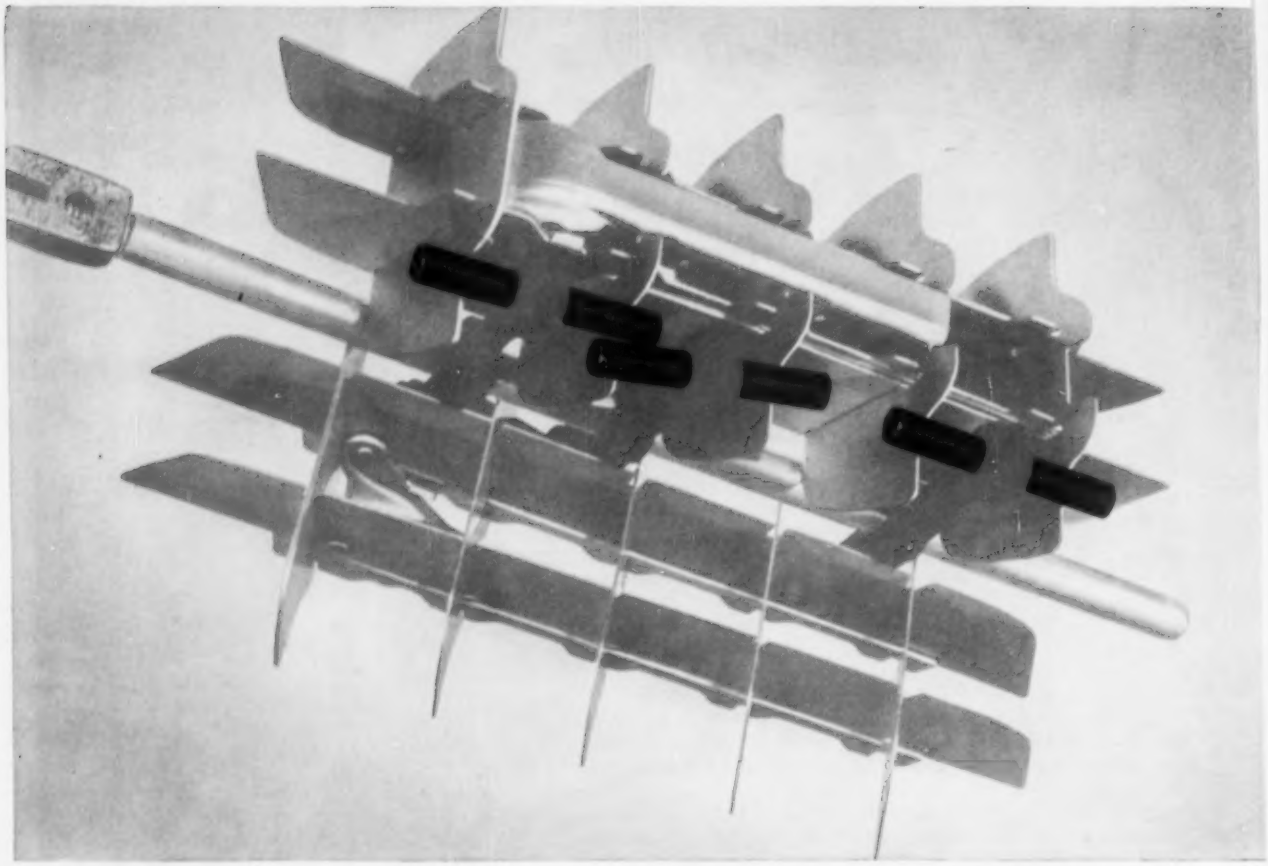

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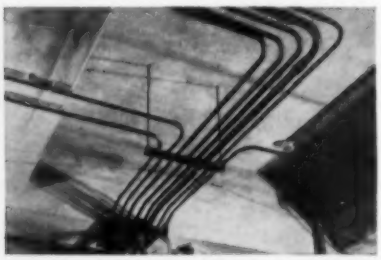

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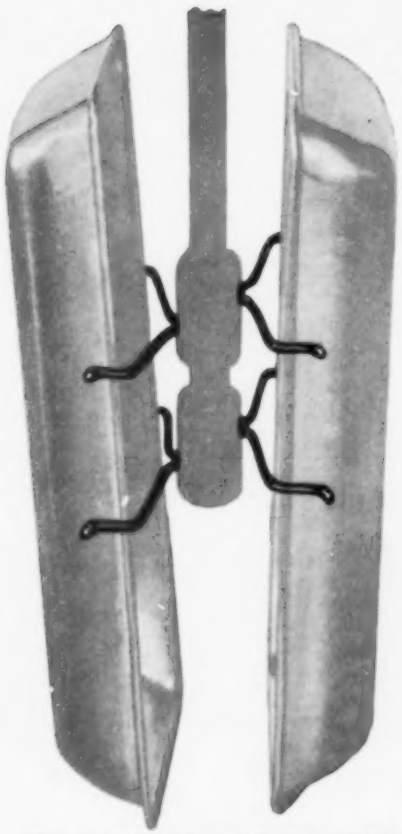

Experimental anodizing racks utilizing Titanium have proved so successful that plans are being made for quantity production. New design will take full advantage of the properties of Titanium for the entire assembly.

Up to now, aluminum has been considered to be the most satisfactory rack material for the anodizing of ice trays and grids.

But, its use has been expensive and time consuming. For example, prior to each anodizing cycle a stripping operation is required to remove the anodic film formed for electrical contact on the previous cycle. And, during each anodizing and stripping cycle a considerable amount of aluminum is dissolved from the racks.

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HOUSTON—M. K. Griggs Co., Phone: CApitol 8-2261 — 7-5523.
KANSAS CITY, MO.—Industrial Electro-Gas Equip. Co., Phone: Victor 3154.
ATLANTA—A. J. Mueller Co., Phone: CHerokee 0185.
TULSA—Ward & Kimball Chemical Co., Phone: GIbson 7-0168.

ALLIED

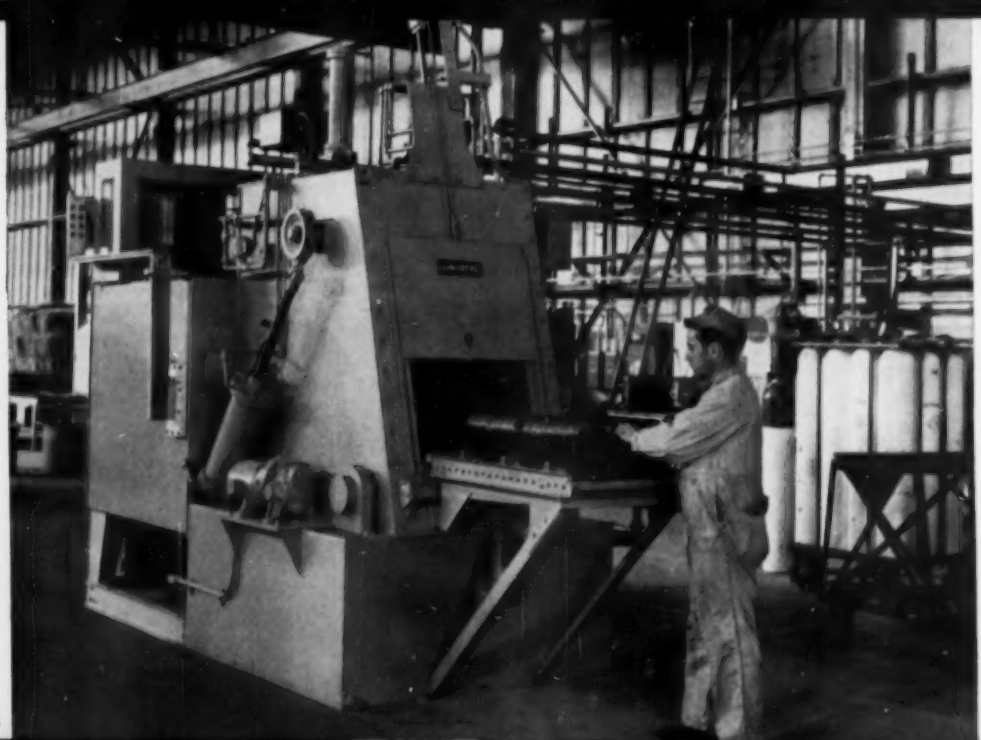
New Lindberg electric furnace with CORRTHERM element at Allied Metal Treating Corporation, Kenosha, Wisconsin. This furnace is used 24 hours a day, 6 days a week, for carbonitriding, clean hardening pinion gears, hardening crank shafts after carburizing and carburizing small gears and shafts.

EKLUND

Installation of new Lindberg furnace with CORRTHERM electric element at Eklund Metal Treating, Inc., Rockford, Illinois. Furnace used 24 hours a day, 7 days a week, for carburizing gears and machine tool parts, carbonitriding sheet metal screws and automotive parts, and hardening and tempering bolts.

PERFECTION

Lindberg electric furnace with CORRTHERM element just installed at Perfection Tool & Metal Heat Treating Company's Lombard, Illinois plant. This furnace is being used 24 hours a day, 6 days a week, for carbonitriding and carburizing parts for automotive and farm implement industries.



COMMERCIAL HEAT-TREATERS QUICK TO ADOPT LINDBERG ELECTRIC CARBONITRIDING FURNACES WITH NEW CORRTHERM HEATING ELEMENT

It is significant that commercial heat-treaters, always in the lead in the acceptance and development of better heat-treating methods, have been among the first to appreciate the revolutionary advantages of Lindberg's newly announced CORRTHERM electric heating element.

Recent Lindberg CORRTHERM-equipped furnace installations in plants of three leading midwestern commercial heat-treaters are shown on the opposite page.

Where electricity is the preferred source of heat Lindberg furnaces with CORRTHERM provide to the fullest degree the versatility and dependability required in efficient commercial heat-treating. Ideal for carbonitriding, they are readily applicable to other processes—carburizing, carbon restoration, bright hardening or annealing, and normalizing.

Whether your heat-treating operations are commercial or captive, large or small, the CORRTHERM element in Lindberg electric furnaces offers you these exclusive advantages:

Low voltage—operates at extremely low voltage. No leakage through carbon saturation.

Atmosphere Circulation—elements act as baffle to direct circulation of convection streams.

Safety—extremely low voltage eliminates shock or short hazards.

Durability—watts density at all time low. Element practically indestructible.

This shows how the new Lindberg CORRTHERM electric heating element fills the furnace with walls of glowing heat. Note also that CORRTHERM is conveniently hung from simple brackets requiring no complicated connections or construction.

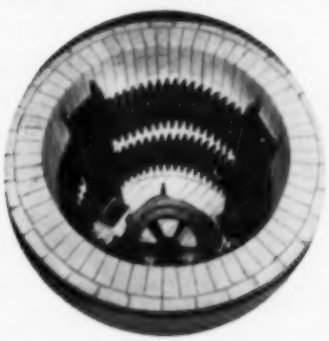
CORRTHERM is an exclusive Lindberg development created in Lindberg laboratories by Lindberg metallurgists and engineers. To find out how its advantages can be applied to your heat-treating processes consult your nearest Lindberg Field Representative. (Look in classified phone book.)

LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 Regentview Ave., at Downey, California

Installation of CORRTHERM elements in one of two large rotary furnaces just erected in the field by Lindberg's associate company, Lindberg Industrial Corporation.



Installation of Lindberg CORRTHERM-equipped carburizing pit-type furnace in plant of Lindberg Steel Treating Co., Melrose Park, Ill.

Safety! Extremely low voltage makes CORRTHERM elements completely safe. Let operator or work load bang it if they will. Neither element nor operator will be hurt.

Complete instrumentation!

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Riehle Universal Testing Machines — whether hydraulic or mechanical — can be equipped with the most modern and flexible autographic strain measuring instrumentation. The Riehle-built Recorder is located under the writing table of the Indicating Unit with its controls placed conveniently on the console. A complete family of recorder accessories is available — comprising various types of strain measuring instruments for magnification ratios up to 1000:1, strain rate indicator and time interval marker. Mail coupon for further information.

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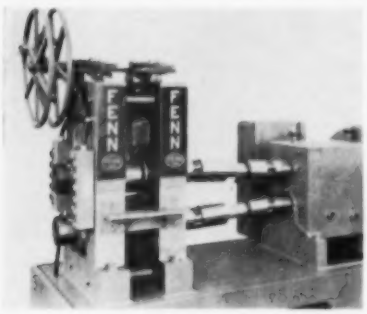
APPLICATION and EQUIPMENT new products

Laboratory Rolling Mill

A new combination rolling mill, especially designed for laboratory and featuring a drive which permits 2-high operation, 4-high operation with back-up rolls driven and 4-high operation with work rolls driven, has been announced by Fenn Mfg. Co. Drive couplings can be changed in a few

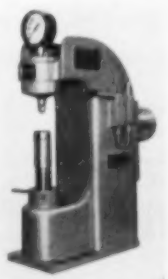


minutes to shift from back-up roll drive to work roll drive. To shift from 4-high to 2-high operation, the work rolls and their bearings are removed. By varying the drive and the number of rolls used, this mill operates over a range of reductions from breakdown rolling to thin gage. The accompanying illustration shows the mill set for back-up roll drive.

For further information circle No. 837 on literature request card, page 32-B.

Hardness Tester

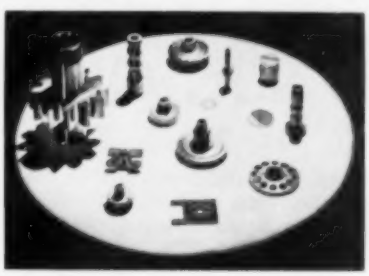
A new motorized Brinell hardness tester has been announced by Steel City Testing Machines, Inc. The Brinell load, adjustable by turning a screw, is provided by a motorized hydraulic pump, with the oil reservoir contained within the machine frame. Operator applies the load by depressing a lever on the side of the machine, holding it down for the desired time interval. releasing the lever instantly releases the load. The Brinell ball penetrator has a ¾ in. stroke. When testing a series of pieces of about the same thickness, it is not necessary for the operator to readjust the height of the anvil for each test.



For further information circle No. 838 on literature request card, page 32-B.

Nitriding

The Standard Steel Treating Co. has announced the development of a new process for nitriding stainless steel. The Supercase process has been used by electronics, carburetor, transmission, aircraft and small parts manufacturers. Because an extremely hard case is obtained by this process, only a very thin case is required. Normal case depth ranges between 0.0003 and 0.0007 in. Supercase may be removed, the parts reworked and then renitrided. It may also be done on a



selective basis. Martensitic, ferritic as well as austenitic steels may be treated by this process.

For further information circle No. 839 on literature request card, page 32-B.

TV Inspection

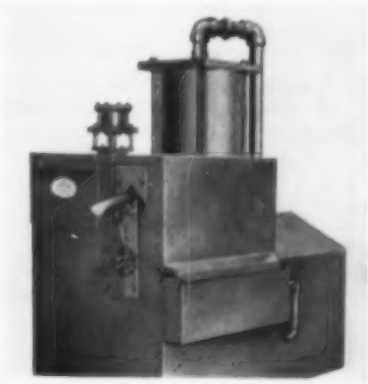
A new X-ray inspection system which produces an image that is 10,000 times brighter than that on the conventional fluoroscopic screen has been announced by General Electric's X-Ray Div. The system produces an image directly, by electronics, from the X-ray source, eliminating the complexities of converting the X-ray image into a light image before intensifying it. The X-ray beam passes through the object being examined and strikes a photo-conductive layer of lead-oxide which has been painted on the inside of a special

8½ in. diameter TV pick-up tube. A low-speed (250-volt) electron beam scans the latent image on the lead-oxide layer and presents it, electronically amplified, on a TV viewing tube. The signal created by the scanning beam can be recorded on magnetic tape and kept for permanent record or the image may be photographed from the viewing screen.

For further information circle No. 840 on literature request card, page 32-B.

Billet Descaler

A new billet descaler which employs a 2200 psi., triple-nozzle water spray has been announced by the Richards Co. It is self-contained and portable. Only compressed air is required for power. Billets are inserted in the unit



YOU'RE SURE OF CLEAN, BRIGHT PARTS WHEN YOU USE SUN QUENCHING OIL 11

The success of your bright quench depends largely on the oil you use. Partial breakdown of an oil in service results in dirty parts. Many times, even a new oil causes failures by staining parts.

High-quality Sun Quenching Oil 11* will give you clean, bright parts from the time you put it in your tank. And, because of high thermal stability, Sun Quenching Oil 11 will continue to give you clean bright parts for long periods.

Most economical because of its low initial cost and long life, Sun Quenching Oil 11 gives uniform quenching in any system. A high flash point eliminates fire hazards.

For complete technical information on how Sun Quenching Oil 11 can assure you of clean, bright parts, see your Sun representative or write for free Technical Bulletin 29.

FREE TECHNICAL BULLETINS

The following free technical bulletins on Sun Quenching Oils are available: Sun Quenching Oil 11 (Bulletin 29); Sun Quenching Oil Light (Bulletin 37); Sunquench 78 (Bulletin 45). Also, pamphlet entitled, "Sun Quenching Oils."

Write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-4.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

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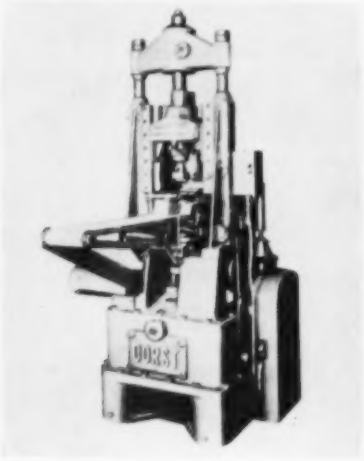
and the water spray is automatically released. Production capacity is rated at 240 to 360 billets per hour for billets up to 6 in. in diameter. Provisions are made for hand, conveyor or pusher loading.

For further information circle No. 841 on literature request card, page 32-B.

Powdered Metal Press

A 110-ton Dorst automatic powdered metal press has been announced by Arnhold Ceramics, Inc. The new press is capable of producing 4 to 20 pieces per minute depending on the intricacy of the part. Special features of the

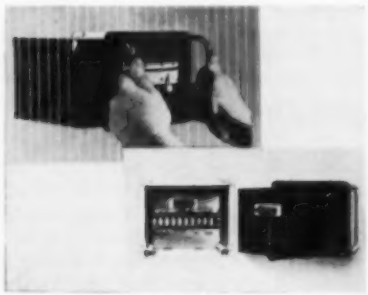


press include adjustment controls with micrometers for the prepress movements, automatic fill, press and ejection of the material, variable speed drive, capacity up to 20 strokes per minute and pickup mechanism and conveyor belt to remove pressed parts automatically.

For further information circle No. 842 on literature request card, page 32-B.

Temperature Control

A plug-in instrument housing assuring continuous operations involving temperature control has been announced by West Instrument Corp. This new accessory is applicable to all West instruments, being applied at the factory or furnished in kit form to be installed by the user. The new

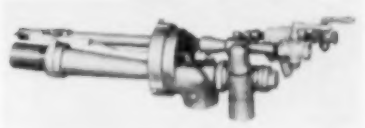


accessory consists of two units—the complete temperature control with hand grips and mounted self aligning plug and the housing which receives the first unit and provides the matching socket and external wiring terminal block. Gold-plated contacts, wiping action and spring loading in the plug and socket assure trouble-free operation.

For further information circle No. 843 on literature request card, page 32-B.

Burners for Radiant Heating

Eclipse Fuel Engineering Co. has announced a special series of burners designed for application to radiant heating tubes used in industrial furnaces and ovens for the wide distribution of indirect heat. These RT burners operate on air pressure of approximately 8 oz. and low pressure gas, normally below ½ lb. They are equipped with a single air supply opening, but an external adjustment makes it possible to vary the amount of primary air to be mixed with the gas. The gas and primary air begin combustion at the end of an alloy nozzle in a secondary air stream. By reducing the velocity of the gas and air flow, a long, slow burning flame is secured which gives very uniform heating through a long length of tube. Burners are made in two sizes and by use of adapters these two sizes can be utilized to fire radiant



tubes with outside diameters ranging from 3¾ in. to 8½ in. The burners will fire from 250,000 to 400,000 Btu. per hr. operating on 8 oz. of air.

For further information circle No. 844 on literature request card, page 32-B.

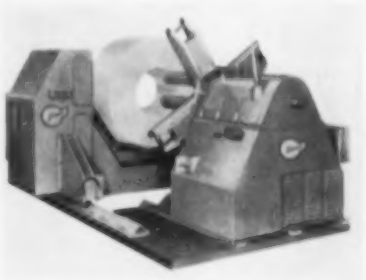
Bright Nickel Plating

New high-speed bright nickel plating process with deposition rates 100% higher than the fastest processes available today has been announced by Hanson-Van Winkle-Munning Co. Practically any existing nickel plating process can be converted to the Levelume process as no special auxiliary equipment is needed and tanks have to be cleaned and bleached only. Newly developed addition agents make it possible to use an activated carbon pack in the filter for the plating solution. This continuously removes harmful organic contaminants.

For further information circle No. 845 on literature request card, page 32-B.

Coil Loader

Sesco, Inc., has announced a new power-lift coil loader. Lateral movement of the loader is obtained as it is mounted on rails, thus permitting



freedom of loading of coil. The coil is elevated to obtain core alignment and then is transferred laterally on to the expander arms of the centering reel. The complete movement of the coil, both lateral and vertical, is by electrical power and is push-button controlled. The model shown is designed for loading a single coil. However, loaders can be built to handle multiple coils and to specifications to handle coil weights up to 40,000 lb.

For further information circle No. 846 on literature request card, page 32-B.

Ultrasonic Soldering

Aeroprojects, Inc., has announced another model of Sonobond ultrasonic fluxless soldering equipment. The unit is a large hand model designed to solder or coat aluminum, copper, brass, silver or magnesium. The ultrasonic soldering head has a ⅝ in. diameter soldering tip, readily changeable to other standard or special tips by screw connection. Driven by a 110 rf. watt ultrasonic generator, the soldering head is air cooled for con-

tinuous operation. The equipment is designed and built for heavy duty industrial use. This model will accommodate a variety of soldering tips, ranging in size from a small pointed tip to ⅝ in. in diameter.

For further information circle No. 847 on literature request card, page 32-B.

Leak Detection

A protection tube leak-checker providing a new method of detecting

molten or gaseous leaks in thermocouple protection tubes immersed in liquid materials has been announced by Peerless Electric Co. The instrument is designed to prevent inaccurate temperature readings and control in salt bath and melting furnaces. It uses the conductivity of molten or gaseous salt or metal to indicate leaks. A special warning circuit connects the thermocouple lead wire with the bath tank. Molten material leaking into the protection tube from the tank closes this circuit.

For further information circle No. 848 on literature request card, page 32-B.

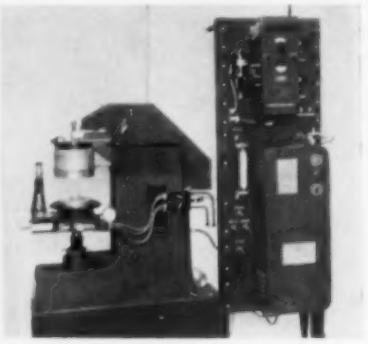
Rhodium Plating

A rhodium-plating solution designed to produce heavier deposits with lower stress in a shorter space of time has been announced by Baker & Co. It plates up to 0.001 in. in 70 min. It can be used without modification of present equipment. This bath produces deposits for decorative purposes or for many electrical and electronic applications. In general, rhodium protects against corrosion and improves efficiency whenever a low-resistance, long wearing, oxide-free contact is required.

For further information circle No. 849 on literature request card, page 32-B.

High Temperature Microhardness Tests

An instrument for microhardness testing at elevated temperature has been announced by Comstock & Wescott, Inc. It permits making indentations with a Knoop indenter which are within 0.0002 in. of a desired spot, at temperatures of 500 to 1250° F. The furnace enclosing the specimen and the indenter is in two parts. The upper part is fixed, while the



lower part is mounted on a stage permitting horizontal movement in two directions as well as vertical movement. In the uppermost position, the opening between the upper and lower parts is closed by a mercury seal, and the specimen protected against oxidation by a hydrogen atmosphere. The spot to be tested is first located by means of a fixed microscope mounted above a stage identical to the one on the instrument. The specimen may then be transferred to the instrument and by a corresponding adjustment of its stage an indentation can be made at the desired spot.

For further information circle No. 850 on literature request card, page 32-B.

Wire Baskets

The Chas. Wm. Doepke Mfg. Co. has announced the addition of wire baskets to its line of parts handling equipment. Sizes offered are from 18 by 10 by 3 in. to 24 by 14 by 12 in. Special baskets and inserts may be

designed and produced to meet individual requirements. Regularly furnished in bright basic steel wire, they are also available in other materials, including stainless steel.

For further information circle No. 851 on literature request card, page 32-B.

Build-Up Wire

The Air Reduction Sales Co. has announced a new automatic build-up wire for use with the submerged arc process. It responds to heat treatment and can be applied to all ordinary A.I.S.I. and S.A.E. steels. It has high impact strength and good wear resist-

GASMACO offers the metal processing industry *automation* in heat treatment . . . Automatic Harden, Quench and Draw Units . . . Automatic Annealing Equipment . . . Automatic Gas Carburizers. This means greater production, lower costs and consistent duplication of metallurgy.

GASMACO furnaces can be supplied with or without protective atmosphere. Any furnace small enough for rail shipment can be completely erected in our shop and shipped ready for operation.

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Check first with GASMACO for latest industrial furnace designs.

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GAS PLANT EQUIPMENT
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NATIONAL CARBON COMPANY'S **CARBON AND GRAPHITE NEWS**

NATIONAL CARBON COMPANY'S

CARBON AND GRAPHITE NEWS

APRIL 1956
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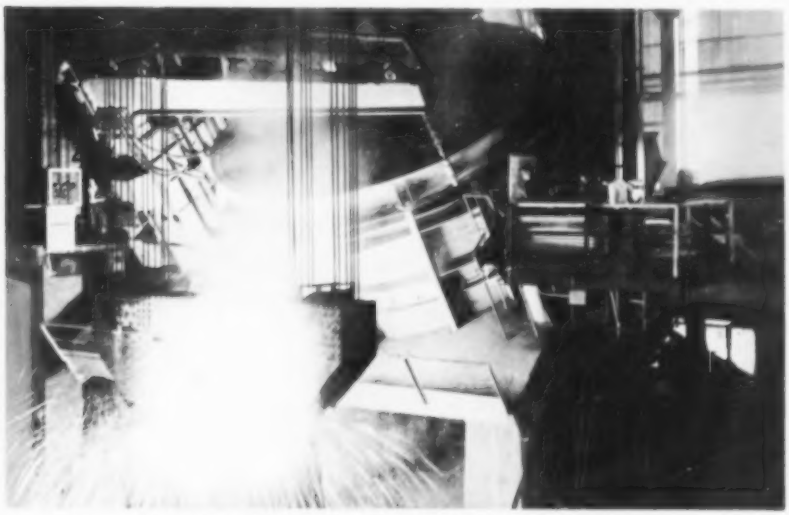
VOL. 3 NO. 1

ELECTRIC FURNACE STEEL BOOMS

Carbon Steels in Electric Furnace Up 55%; Share of Market Increases



Largest Electric Arc Steel Furnace Installed To Date.
Built by American Bridge Company for McLouth Steel Corporation.

Although still a small fraction of total steel, plain carbon steel produced in the electric furnace jumped sharply in 1955, showing a tonnage increase, according to industry analysts, of 55% over the 1954 figure.

Of still greater interest is the fact that the electric furnace carved out for itself in 1955 a bigger slice of the carbon steel pie than it enjoyed in any previous year, increasing its share of market by 23% over the 1954 figure.

Swing to Electric Furnaces

Behind the shift to the electric furnace are two very significant factors. These are the marked advances in furnace technology and a new appraisal of the economic considerations pertinent to the current production and capacity situation.

Advanced furnace designs and the availability of electrodes which can take full advantage of these designs, have been notable factors. The net result has been a major betterment of the electric furnace's competitive position.

Cite Electric Furnace Advantages

Informed industry sources point to several reasons why the popularity of the electric arc furnace has spurted. Among these are the following:

- **Lower Installation Costs** – A recent comparison of installation costs, open hearth vs. electric furnace shops for the production of plain carbon steel showed that capital costs for the electric shops were approximately 40% lower than the open hearths'.
- **Shorter Construction Time** – Construction time for steelmaking facilities is roughly proportional to capital outlay. Thus, an electric furnace shop with its lower capital requirement usually can be built more rapidly than an open hearth shop of like capacity.
- **Greater Flexibility** – An electric furnace can be economically operated on a one shift basis or a 24 hour basis, – 5 days a week or 7 days a week. Little time or power loss is involved in placing it in production or shutting it down. Depending on the demand,

continued on next page; column 1

DUCTILE IRON USES EXPANDING RAPIDLY

Production Tonnage up 150% in 1955

Ductile iron, a new wonder metal developed by International Nickel Company, is proving one of the most outstanding foundry achievements since malleable iron. Combining the processing advantages of cast iron with many of the engineering advantages of steel, it largely bridges the gap between cast iron and steel.

A long list of valuable properties make this new iron much in demand in such diverse industries as aircraft, farm machinery, tool and die, pulp and paper, petroleum, automotive and many more. Ductile iron, or nodular iron – as it is oftentimes called – can be twisted, drawn, bent and otherwise deformed without fracture and is much stronger than ordinary grey iron. Also, it shows exceptional resistance to impact and to oxidation and growth at high temperatures.

Made in Electric Arc Furnaces, Cupolas

Many foundries are discovering in the versatile electric furnace just the tool for making ductile iron, a product which demands high purity cast iron as a starting material and close metallurgical control throughout the process. The electric arc furnace, in addition to such operating advantages as flexibility, high time and energy efficiency and "on-off" economy, provides easy control of slag-metal reactions and bath temperatures so essential to close analysis products.

Another approach to the manufacture of ductile iron, which is receiving increasing attention, makes use of the

continued on page 3

100th ANNIVERSARY

1956—100th anniversary of the birth of E. G. Acheson, inventor-industrialist whose perfection of manufactured graphite ensured the electric arc furnace's success as a cornerstone of molten metallurgy. Significantly, 1956 is also the golden anniversary of the use of that furnace in this country. For more about Dr. Acheson and his part in framing our American Industrial Empire, see next page.

Baking Capacity Expanded in Latest Move to Meet Increasing Industrial Needs

Increased Electrode Demand Responsible; Pace Destined to Continue

Substantial progress toward readying 20 million pounds of new baking capacity at National Carbon's National Plant, Niagara Falls, N. Y., has been reported by W. H. Feathers, Vice President, Industrial Products.

Major rearrangements and additions, begun last year at this veteran National Carbon electrode plant, will be completed within the next two months, according to Mr. Feathers.

As in the cases of the company's other electrode plant expansions of the last few years, the Niagara Falls step was taken to keep pace with the heavily increasing demand for furnace electrodes – particularly the larger sizes.

The new installation involves large size gas baking furnaces and a monetary investment, which while impressive enough in itself, represents only a small fraction of the huge amounts National Carbon has poured into its 5 electrode plants in the last five years. As a result, the Clarksburg, West Virginia, plant, the National, Acheson and Republic plants at Niagara Falls, N. Y., and the Columbia, Tennessee plant have all made big forward strides. Of the group, Columbia, Tennessee–showcase plant for the entire carbon industry – has seen the most spectacular growth.

The rapid growth of the electric arc furnace, together with responsible predictions of steel industry analysts, sustain National Carbon's confidence in the future – a confidence the company has set out to back with product.

W. H. Feathers, Vice President Industrial Products, National Carbon Co.
"... Confidence ... backed by product"

Cited particularly are two significant trends:

1. Electric arc furnaces of all types in the U. S. now number over 2,000 with the number growing rapidly, as 1955 alone brought furnace makers more orders than ever before.

2. In the electric arc furnace's major application field, steelmaking, production is expected to soar some 40% in the next five years alone.

On the basis of the carbon industry's historical growth since its founding in the last century – and in the light of predictable demands from an insatiable, multiplying population – carbon men see many more expansions to come.

ELECTRIC FURNACE

continued from page 1

the electric furnace can be operated either in excess of, or below, rated capacity and can turn out any kind of steel the situation requires. Production experience shows the electric furnace has a greater availability than the open hearth.

- **Smaller Space Requirements**—An electric furnace shop designed to produce 500,000 tons of ingots annually will cover only about 75% of the ground area required by an open hearth shop of like capacity, according to a study by one major steel company.
- **Closer Temperature Control** – Operating men agree unanimously that the electric arc furnace lends itself readily to temperature control. The rate of heat input is limited only by the rate of heat transfer in the bath and temperature may be raised in a matter of minutes.
- **Product Quality**—The electric arc furnace can hold rigid product specifications on all types of steels.

The production of plain carbon steel, in the electric furnace, often shows lower costs than other types of furnaces making this product. Power cost economies, improved electrode performance and prevailing market factors are important considerations in arriving at a final determination.

Ready Electronic Products Laboratory

A new electronic products development laboratory has been established by National Carbon at its Cleveland Edgewater plant. It will be in full scale operation this June.

New products derived from the company's expanded research in the field of solid state physics will be developed

continued on next page; column 3

National Carbon Company's
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Dr. Edward Goodrich Acheson

Man of Genius Man of Foresight
Man of Fortitude

This is the man whose 100th Anniversary is being commemorated this year.

It required genius to convert repeated failure into success – foresight to attack so many experiments that had been attempted many times before, but without success – fortitude to keep on in the face of misfortune, ill health and other adversities.

Dr. Acheson was born on March 9, 1856, in the southwest corner of Pennsylvania, of good sturdy, pioneering stock; a heritage that probably had much to do with shaping his destinies. The total accomplishments of Dr. Acheson throughout his busy life are too many to record here, but the revolutionizing effects of his contributions –"Carborundum" abrasives Manufactured Graphite, the Electric Resistance Graphitizing Furnace, and Colloidal Graphite bear repeated emphasis.

It is certain that Dr. Acheson's part in the development of manufactured carbon and graphite and in the field of electrothermal phenomena, made possible the successful electric arc furnace. And, it is just as certain that without

continued on next page; column 1

MAKE ULTRA PURE GRAPHITE ANODE

Recent successful production of an ultra high purity graphite anode for use in a mercury type caustic – chlorine cell has just been announced by National Carbon Company.

Electrolytic first cousin of the electrothermic (electric furnace) electrode, the new "National" graphite anode is the purest graphite anode yet produced and lasts longer than previous graphite anodes approximating its purity.

Asked for more details on the new anode, an Industrial Products Department spokesman explained, "we use a selected raw material and process it by an exclusive National Carbon development which takes full advantage of the superiority of that raw material."

It was pointed out further that the company's own purification method was a prime factor in the successful manufacture of graphite anodes of very low vanadium content. "In fact," said the spokesman, "we recently met a leading chlorine-caustic producer's stringent specifications for graphite anodes with a vanadium content of only 2 parts per million. In the bargain we delivered an all-round better product than he had been able to obtain from his only previous source, Germany. So, we've scored twice – made a better anode – brought home a welcome piece of business."

DR. ACHESON

continued from preceding page; column 3

the arc furnace, our economy today would be completely different–and far less advanced.

So, it is equally fitting that the 50th Anniversary of the first U. S. electric arc furnace for steel making is also being celebrated this year. This furnace was installed at Halcomb Steel Company, Syracuse, New York, in 1906. Designed by Dr. Paul T. Heroult, it was a direct arc, single phase, three-ton capacity unit, operated in duplex with an open hearth. The era of stainless steel, high alloy specialty steels, fine tool steels, and the very prolific family of ferro-alloys began in 1906, to be followed by common steel grades, specialty irons, elemental phosphorous and many other products.

Too great a tribute cannot be paid to Dr. E. G. Acheson and to the first steelmaking furnace–two events that are inexorably related.

Date line . . . 1886

National Carbon Company organized for the modestly stated purpose . . . "to manufacture miscellaneous carbon products."

Electric Arc Furnace Capacity Sets Record In 1955

The record tonnage capacity of electric arc furnaces in operation at the end of last year, and the orders for new furnaces already on the books for delivery early this year, are indicative of still new arc furnace tonnage records to be posted in 1956.

While the installed capacity is of great importance, there is even more significance in the upward trend of unit installations coupled with the increase in the physical sizes of the new furnaces. Today's newest 200 ton giants with their 24½ foot diameter hearths dwarf the first steelmaking electric furnace in this country, a three ton model with a small, rectangular hearth.

The reasons for the increasing utilization of the electric arc furnace in melting, smelting, reducing or refining, are wrapped up in its versatility and flexibility. These advantages keep it on tap whenever needed and for whatever product is required–steel, phosphorous, calcium carbide, ferro-alloys, non-ferrous metals, or any of the many other electric furnace products.

DUCTILE IRON

continued from page 1; column 2

carbon lined cupola. "National" carbon cupola linings last as much as 5 times longer in continuous operation than traditional cupola refractories, according to National Carbon engineers. Furthermore, carbon linings are neutral – the operator can employ acid, basic or neutral slags as dictated by his various metal charges.

Characteristics Discussed

Informed sources explain that the change in the microstructure of cast iron, which makes it so ductile, derives from adding very small percentages of magnesium, cerium or certain other elements to the molten iron just before casting. This addition converts into spheres or spheroids, the flake graphite as found in grey iron or in the compacted aggregates characteristic of malleable iron. With the embrittling and weakening effects thus removed, the microstructure becomes stronger.

Ductile iron can be heat treated much the same as steel; it also can be welded, soldered and brazed and, because of its good fluidity in the molten state, it can be cast in intricate shapes and thin-sectioned parts.

Cost Factors

Ductile iron costs more than cast iron but less than steel. The foundry and cleaning costs are lower than for steel castings, with machining cost considerably lower because of faster cutting and longer tool life. And, good castability plus excellent engineering properties often recommends ductile iron as a replacement for expensive forgings and weldments.

Giant "National" carbon electrode is 53 inches in diameter by 110 inches long and weighs 17,000 pounds. It is shown here by Joseph P. White, Assistant Plant Manager of National Carbon's Republic Plant, Niagara Falls, New York.

Unveil Giant New Furnace Electrodes

National Carbon Company has unveiled another history-making advance in the manufacture of large carbon and graphite furnace electrodes.

Company spokesmen report 1955 saw the forming of the world's largest electrode – a 9 foot long, 53 inch diameter carbon cylinder scaling 17,000 pounds. During the same period National Carbon also introduced the biggest graphite electrode ever made, a huge cylinder 45 inches in diameter, 110 inches long.

Both types of electrodes are for submerged arc furnaces, their full significance is expected to be reflected in larger, more efficient submerged arc furnaces, according to National Carbon spokesmen.

ELECTRONICS LAB

continued from preceding page

by this new organization. Many of the products are expected to be of types not directly related to National Carbon's present lines of consumer and industrial products, according to company sources close to the new undertaking.

NATIONAL CARBON LAUNCHES ELECTRODE EDUCATION SERIES

Furnace Operators Benefit From New, Free Program; Better Furnace Efficiency, Lower Costs Sought

National Carbon Company has kicked off another new, far-reaching educational program to help furnace operators get better performance through improved utilization of the company's complete range of electrode products, according to Fred B. O'Mara, Manager of the Electrode Product Sales Department.

Introduced at last December's Electric Furnace Steel Conference, A.I.M.-M.E., Pittsburgh, Penna., the new program represents National Carbon's latest assist in a long line of programs designed to help its customers get the greatest operating efficiency from furnace electrodes. Spokesmen were quick to point out that National Carbon was the country's pioneer electrode producer and the first organization to conceive, and so broadly implement, comprehensive training for its customers' furnace operators.

Give Program on Request

"We give our oral-visual educational series on request, right at the customer's plant – no strings attached," declared J. W. Shea, Manager of the Electrode Service Department. "Of course, we have to schedule carefully because of the program's popularity." He stressed that the series involved slides, lecture-demonstration and spontaneous audience participation – it is not a "canned program".

Commenting briefly on the company's shirt-sleeve faculty who present the course, Mr. Shea said, "We've got the biggest, most experienced service group in the business. Our men are carbon and graphite experts. They've worked on developing and engineering the material, they've produced it in our plants, they know its application."

Operators Should Understand Carbon

At the heart of the new program is the recognized need for operators to understand fully the recommendations made by the electrode manufacturer and the reasons underlying those recommendations. The operator should know something of the unique characteristics of carbon and graphite and what occurs when electrodes made of these materials are used in an electric furnace.

"Since the ultimate destination of National Carbon's electrodes is the electric furnaces in its customers' shops," said Mr. Shea, "we in the Electrode Service Department are particularly anxious to help our customers get the very best operating results. This means taking all the indicated steps to insure that the electrodes operate at maximum efficiency so that our customers will benefit from *all* of the service which we have built into our product."

Electrode Service Department engineers explained that an electrode must be, first of all, a good electrical conductor. It must be strong to resist mechanical breakage. Also, it must have excellent thermal properties to stand up to arc temperatures which climb above 6,000 degrees F. Carbon and graphite are the only materials with the requisite properties.

How Electrodes are Consumed

Mr. Shea declared, "people are usually quite surprised to learn that furnace electrodes can be consumed in five different ways – it's not just a matter of 'burning up'. Sublimation, adsorption, dipping, breakage and oxidation are all factors."

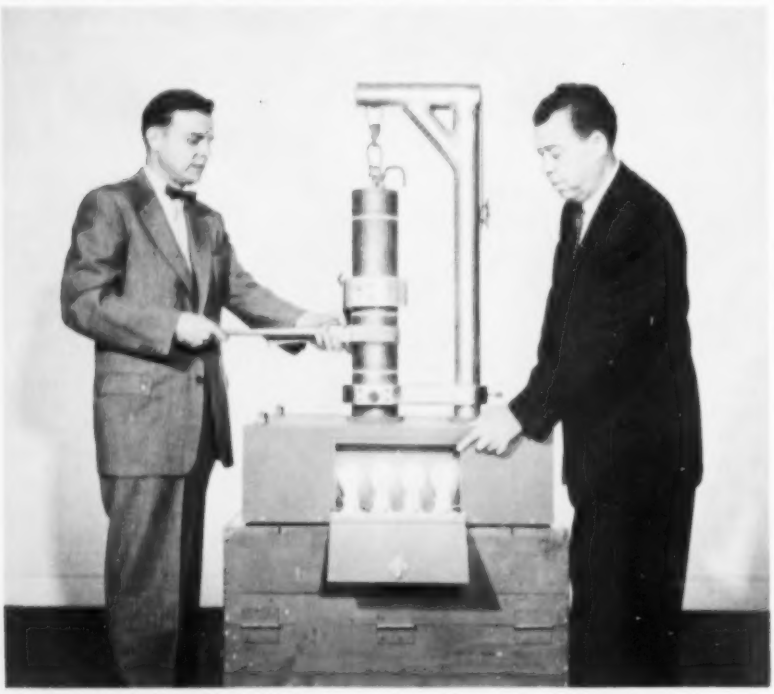
Sublimation, adsorption and dipping all take place at the arc tip. Although the first two are not subject to regulation, it is possible to reduce electrode consumption by changing dipping practice. Dipping refers to a method some operators employ to raise the carbon content of the melt by lowering the electrode and dipping it directly into the molten metal.

Oxidation and breakage occur higher up the electrode column. They are more easily controlled by such means as temperature manipulation, cleanliness, maintenance, mechanical adjustment and careful handling. In this area lie real opportunities for electrode conservation, according to National Carbon's electrode experts.

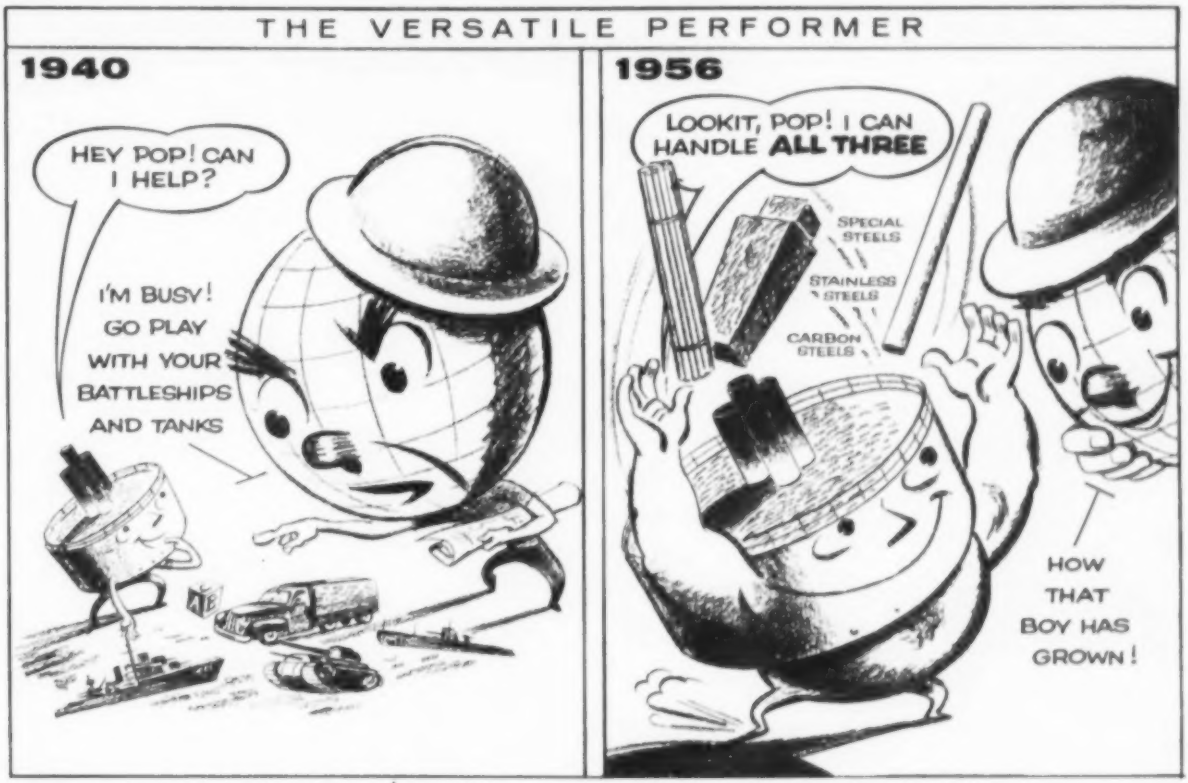
Feature Electrode Demonstration Device

One of the most universally popular features of the lecture-demonstration series is a novel electrode demonstration unit which simulates all the steps in electrode joint assembly. Conceived and built by the electrode service group, the unit demonstrates how dust and dirt, joint chips and socket clamping affect operation. It also shows loose joints vs. tight joints in relation to electrode efficiency.

Queried on the reaction to the new service program, Messrs. O'Mara and Shea indicated that it has been excellent. To cite just one case, a highly placed steel executive has recently thrown his enthusiastic endorsement behind the program and has urged its full exploitation within his own organization. Better furnace efficiency at the lowest cost is his goal, too.



R. L. Westlake, Electrode Service Engineer (left) and J. W. Shea, Manager, Electrode Service Department test novel electronic device for simulating steps in electrode joint assembly.



National Carbon Lists Latest Free Literature

Several recent company publications are available for the asking. To receive any of the following, just address Advertising Department, National Carbon Company, Dept. CGN, 30 East 42nd Street, New York City 17, New York. Please include your name, title and company address.

1. Past issues of the quarterly "Carbon and Graphite News" with main articles as follows:

August 1954–Electric Furnace Steel – Past, Present and Future by W. B. Wallis.

December 1954 – The Electric Arc Furnace – An Appraisal for Management by Charles W. Vokac.

March 1955–Flexibility of the Electric Arc Furnace – What It Means to the Steel Producer by E. A. Hanff.

July 1955 – The Indirect Arc Electric Furnace Development and Application by B. W. Schafer.

Sept. 1955 – Electric Utilities and the Electric Furnace by Paul D. Brooks and Paul W. Emler.

Dec. 1955 – Production of Quality Steels in the Electric Furnace by Harry F. Walther.

2. New 6-page Catalog Section S-4905, "National" Graphite for Atomic Energy Applications.

3. Technical Treatise–64-page book "The Production and Properties of Graphite for Reactors". Limited quantities.

4. New 16-page Catalog Section A-4004 "National" Spectroscopic Products.

5. Educational Series for Electrical Maintenance Men, "National" Brush Digest, a bimonthly pamphlet series.

6. 8-page pamphlet describing the characteristics of the first General Purpose Industrial Brush, "National" N-4.

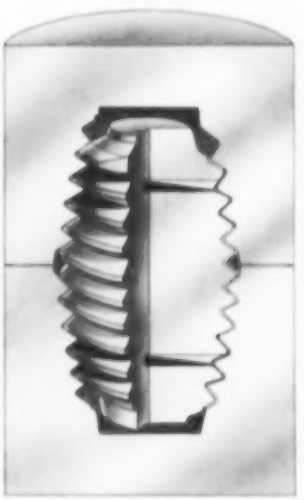
7. New descriptive literature covering "National" carbon products for use in cupola furnaces. Ask for Catalog Section S-5450. Installation sheet is also available–Catalog Section S-5455.

Pitch Reservoir Pin Huge Success — *New Patent Pays Off*

National Carbon's new patented pitch reservoir connecting pin has proved very successful in keeping electrode joints tight.

The new pin, identical with standard, tapered, graphite nipples in size, shape, tolerances, composition and quality, is distinguished by the pitch-filled reservoirs near each end of the threaded portions. As the connecting pin becomes hot, the pitch flows from the reservoir into the threaded section of the joint where it cokes out, cementing and locking the threads of the nipple and socket together. This action occurs at temperatures well within the range of the operating column. No application of cement or dowels is required.

The new pin is proving highly effective in eliminating collar- and nipple-loss at the arc end of the electrode, resulting in greater furnace efficiency. Predictions are that it shortly will supersede the plain-type tapered connecting pin.



World's Largest Carbon Forming Unit— almost entirely automatic – completely fills a 13 story building at National Carbon's Columbia, Tenn., plant.

Midgets at work

Pygmy Electrodes Do Giant Size Job

Some of the 37 preformed special graphite spectroscopic electrodes contained in National Carbon's complete line of spectroscopic products.

Electrodes so small a half dozen fit easily within a thimble – these are the latest additions to National Carbon Company's line of high purity spectroscopic products.

Size-wise, the tiny, preformed electrodes – there are now 37 shapes to meet any spectroscopic need – are a far cry from the multi-ton monsters which fire a modern electric arc furnace. But, they possess an industrial importance completely belying their Lilliputian dimensions.

Like their furnace-borne brothers, spectroscopic electrodes are heat producers. They absorb hearty charges of electricity until their tips, intensely hot, vaporize small samples of unknown elements, or compounds, which the spectroscopist wishes to analyse. Since every chemical element when raised to incandescence produces its own characteristic color lines, or spectra, the trained technician need only identify the emission lines of his unknown sample. Simply, quickly, conveniently he performs his analysis, answers the questions–what and how much?

Today, spectroscopic analysis is a rapidly growing technique–a convenient tool which in many cases is replacing the traditional chemical analytic methods in such broad fields as metallurgy, chemistry and biology. The technique relies heavily on high quality, high purity and uniformity of the graphite used.

Begin New Packaging Program; Changes to Benefit Customers

Graphite Electrodes and Connecting Pins First; Other Products to Follow

Plans for new packaging to benefit customers through improved product protection and identification have been announced by National Carbon Company.

The improvements will encompass the company's entire line of industrial products. First items scheduled for the change are electric furnace electrodes and related products marketed under National Carbon Company's brand name, "National".

One of several proposed designs for electrode connecting pin cartons is discussed by F. B. O'Mara (left), Manager, Electrode Product Sales and C. G. Ollinger (right), Assistant Advertising Manager, National Carbon Company.

According to company sources, the initial project to be tackled is an attractive, durable end cap for 12 through 24 inch diameter graphite electrodes. An industry innovation, the cap fits snugly against the electrode to protect its socket from dust and chipping from the time the electrode is shipped until it goes on the customer's furnace.

NATIONAL
TRADE MARK

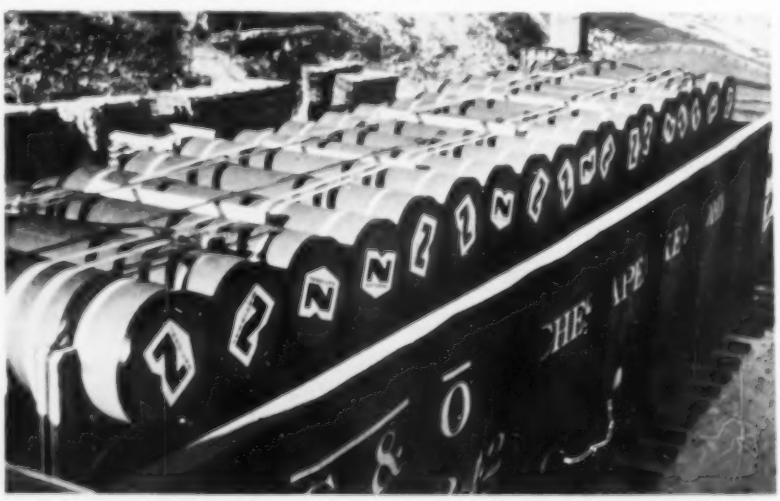
National Carbon's familiar product identification in new dress. Both the term "National" above and the "N-in-shield" device shown on electrodes below, are trade-marks of Union Carbide and Carbon Corporation.

Work on Pin Cartons

Another phase receiving current attention is the package standardization and legibility upgrading on the entire line of connecting pin cartons. Priority has been given to pin cartons for the 20 inch diameter graphite electrode with new cartons for other sizes to follow soon.

The entire program is being coordinated by the company's Quality and Specifications group with help from the Advertising and Sales Departments. The package design specialty firm, Robert G. Neubauer, Inc., is handling designs for electrode products.

It is expected that several months will be required to complete the project for the entire array of industrial products because of the large number of items involved. Included are brushes, lighting carbons, processing equipment and a whole range of carbon and graphite specialties.



New end-caps protect the sockets of these palletized electrodes shown on route to customer's plant.

Reactor Program to Boost Steel Fabricators' Business

Graphite Gets Increasing Role in Atomic Program

A $700 million annual business for manufacturers of reactor components by 1963 is being forecast by authorities in the field. Of this, a sizeable slice is destined for steel fabricators.

Nuclear reactors are, in effect, atomic furnaces fueled by fissionable elements. They leash the explosive power of the all too-familiar atom bomb and make it available in relatively smaller, stretched out doses for man's benefit.

"National" High Density Graphite, 40 inches in diameter, 1.90 gms/cm.³ density.

Of the several types of nuclear reactors, the kind whose end product is electric power is attracting most attention. Power reactors loom as future competitors to today's fuel-steam generated electricity. Some informed quarters predict 2 million kilowatt capacity from power reactors by 1960 with the figure surging to 175 million by 1980.

One of the significant outgrowths of the expanding nuclear program is the increasing importance of high density, high purity graphite for reactor construction and allied uses. Graphite itself has long held a respected place in such diverse applications as processing equipment, brushes for electrical machines, lubricants, illumination and electrolytic and electrothermic electrodes.

In the nuclear field, graphite's chief virtues are its ability to capture wild, potentially dangerous neutrons which speed helter-skelter through the reactor and also its unique property of greater strength at high temperature than at room temperature. Thus, graphite excels as a construction material for moderators, reflectors, shielding and molds and crucibles.

As an aid to understanding more about graphite's nuclear applications, National Carbon Company has recently published 2 works – both have been offered free. One of these publications is a technical treatise – a 64-page book

Typical "National" Graphite Molds and Crucibles Used In Metal Casting. Largest Mold Shown is Nearly 3 Feet Tall.

entitled "The Production and Properties of Graphite for Reactors". The other publication is a less technical bulletin detailing various graphite grades, their characteristics and uses in atomic energy applications.

Carbon Found Ideal For Cupola Furnaces

A promising new metallurgical application of carbon is rapidly developing in the field of cupola refractories, according to National Carbon sources.

Pursuing this trend, the company has embarked on an extensive campaign aimed at showing foundry operators the numerous operating advantages possible when carbon is employed as a cupola refractory. Already, a rapidly increasing number of foundries are endorsing "National" carbon cupola products as the most practicable answer to their refractory problems, it was pointed out.

Among the unique properties of elemental carbon which recommend it particularly for cupola use are these:

- Carbon is not attacked by acid or basic slags.
- It withstands extreme thermal shock.
- It has no melting or softening point.
- It is not wet by molten metals.
- Carbon shows high mechanical strength at all temperatures and its strength increases with increased temperatures.
- Carbon resists abrasion well.

continued on next page; column 2

National Carbon Company Announces Progress on Giant New Research Center

Laboratory to develop future materials today

Union Carbide and Carbon Corporation will begin moving equipment into its new research laboratory at Parma, Ohio, next month, according to spokesmen for National Carbon Company which will manage the new unit for the Corporation.

The new laboratory will carry out basic exploration in physics and the interrelation of physics and chemistry applied to metallic and non-metallic compounds of carbon and analagous compounds. Important contributions to the future requirements of industry are expected to result from these studies.

Dr. Clarence E. Larson
Vice President in charge of Research
National Carbon Company

Among the possible far-reaching developments expected to come from today's investigations are materials for new and improved transistors and related electronic devices, new and improved refractories, and the key to further progress in ferrites – complex inorganic compounds which show promise for automation machinery and computers.

Dr. Robert G. Breckenridge
Director of Research
National Carbon Company

continued on next page; column 1

HAIL "DEVIL'S IRON" NEW MAGNET METAL

A fifty year search for a better magnet steel has paid off in a new Allegheny Ludlum steel which enables size and weight reduction in important electrical equipment.

The new material is a grain oriented silicon steel popularly called "Devil's Iron" – a nickname originating with rollers and pack openers who handled the metal.

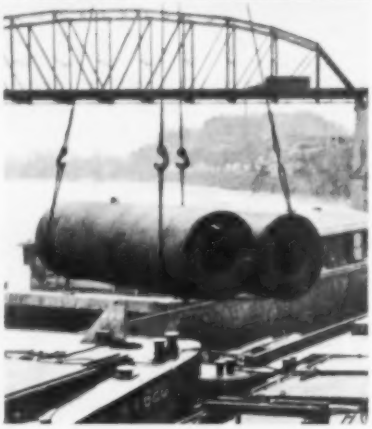
The new silicon steel represents a far-reaching advance in electrical steels for concentric core transformer windings, motor and generator stator parts, business machine and telephone components and a host of other specialized uses.

As a magnet material, grain oriented silicon steel, specially rolled and heat treated makes it possible to get more pull with less power. Also, important advantages are claimed in the conservation of copper and other materials employed in electrical equipment.

NEW RESEARCH CENTER

continued from preceding page; column 3

The new laboratory Center with its substantially augmented scientific staff represents the most recent step forward in National Carbon Company's industrial research activities. The company's organized research program, reaching back to the turn of the century, was initiated when National Carbon established America's first industrial research laboratory in 1902.



NATIONAL

ELECTRODES AFLOAT

Approximately 1,000,000 pounds in one shipment!

The largest shipment of electric arc furnace graphite electrodes ever made is shown in this barge load of 972 graphite electrodes, 20-in. diameter x 72-in. long, each weighing about 1231 pounds. Shipment was made by National Carbon Company, from its plant at Columbia, Tennessee, to a Chicago destination.

CUPOLA FURNACES

continued from preceding page; column 2

The most important factor in establishing carbon's superiority as a cupola refractory, however, lies not so much in any one of its advantageous properties, alone, but rather in the fact that they are all present in every piece of carbon. No other material offers such a combination – an ideal answer for well zone linings, breast and tap hole constructions, slag dams and slag and iron trough linings.

Union Carbide and Carbon Corporation new Research Laboratory at Parma, Ohio

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

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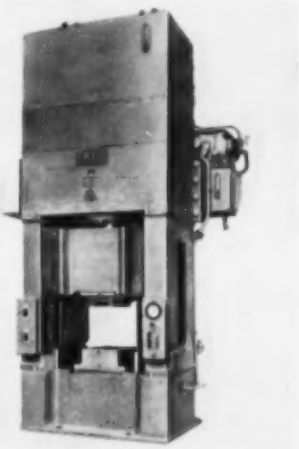
ance. This new wire is designed for use prior to final hardfacing on parts such as tractor rollers and idlers, earth moving shovel parts and cable drums. As a build-up with no final hardfacing it is recommended for the restoration of tractor track rails and links, large shafts, pulley sheaves, mine car and crane wheels.

For further information circle No. 852 on literature request card, page 32-B.

Forging Press

A new special hydraulic forging press has been announced by the Hydraulic Press Div. of the Erie Foundry Co. Rated at 1000 tons, this press is designed to forge jet engine turbine blades. It completes a 6 in. stroke cycle in just 4 sec. This press



incorporates speed control with automatic pressure and precision reversal by means of a special compression and decompression feature. It is of rigid side housing construction with preshrunk tie rods. It is self-contained and can be arranged for semi-automatic single cycle or push button operation.

For further information circle No. 853 on literature request card, page 32-B.

Metalworking Lubricant

American Metaseal has announced Meta-film solid lubricant which may be used on all metals. It lubricates at extreme temperature and pressure ranges, on sealed and inaccessible bearings or assemblies, on bearings adjacent to any surface that cannot be contaminated, on mechanisms that operate intermittently over long periods, on parts where the environment would affect the average organic lubricants, and on parts where dust and solvents present problems. A carefully controlled baking process plays a major role in the ultimate success of this solid lubricant by

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The name BAKER on Rhodium plating solutions means completely dependable quality and performance every time. Baker supplies standard solutions, or special formulae for individual procedures.

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MALLORY·SHARON
reports on **TITANIUM**

This typical punched card records ingot number, specimen number, direction of test, rolling temperature, finish rolling temperature, annealing temperature, annealing time, quenching medium, ultimate strength, yield strength, percent elongation. Approximately 25 cards are needed to record all the facts on each heat.

2,000,000 "bits" of vital statistics make Mallory-Sharon titanium better

● This "data center" at the Mallory-Sharon Research Laboratory is believed to be the first application anywhere of punched card accounting equipment in metals research and development. Here titanium processing data, test results, properties, etc. are coded on punched cards, permitting rapid correlation and use of significant data.

Thus, fast answers can be obtained to researchers' questions, such as . . . what are the comparative strengths and ductilities of weldable alloys? . . . how do variations in titanium sponge hardness affect alloy strength? . . . what are the effects of heat treatment on bend characteristics?

As a result, we're constantly analyzing and using current test and production data to improve alloy designs and properties. And we are able to maintain outstanding quality control . . . to predict properties in advance of processing . . . to certify physical properties of each heat with statistical quality control methods.

This is an example of the technical leadership of Mallory-Sharon, and another reason why Mallory-Sharon titanium and titanium alloys have won an excellent reputation for consistently high quality and uniformity. Call us for your requirements in this lightweight, strong, corrosion-resistant metal.

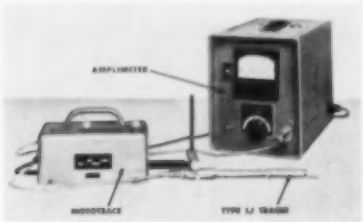
MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti SHARON

assuring the proper forming of the unbroken film on the metal treated.
For further information cicle No. 854 on literature request card, page 32-B.

Surface Measurement

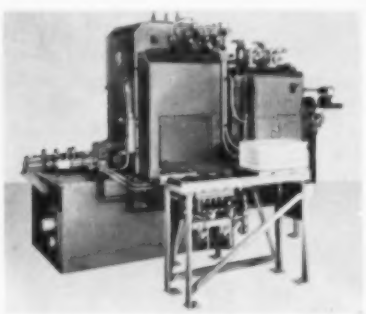
Micrometrical Mfg. Co. has announced the Profilometer, Group II, a portable equipment combination for measuring surface roughness in the shop. Equipment includes an amplimeter, a tracer and a mototrace for mechanical operation of the tracer. The tracer measures on inside diam-



eters as small as ¼ in., outside diameters as small as ⅛ in., flats, tapers and narrow splines and passes through a ¾ in. hole. The mototrace provides a smooth reciprocating tracing motion of 0.3 in. per sec. over any desired length of trace from 1/16 to 2¾ in. The amplimeter shows either arithmetical or rms. average roughness height and has six ranges with full-scale readings of 3 to 1000 microinches.
For further information circle No. 855 on literature request card, page 32-B.

Automatic Batch-Type Furnace

The Dow Furnace Co. has announced an automatic, controlled atmosphere, batch-type furnace which preconditions, loads and unloads the work chamber and quenches the proc-



essed charge without operator handling. Featured on the DOWmatic HC-800 are pressurized operation, double elevator and automatic transfer mechanisms.
For further information circle No. 856 on literature request card, page 32-B.

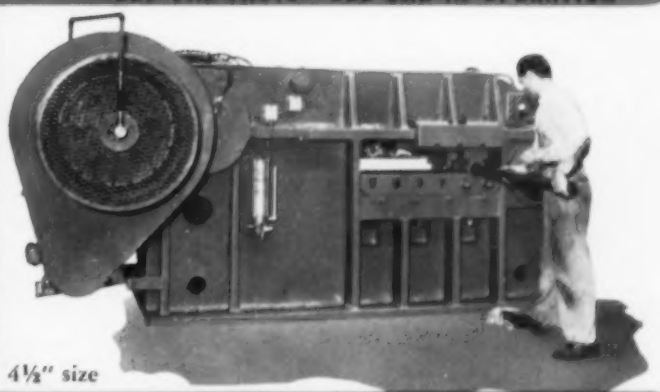
Pressure Gage

An instrument for continuous and accurate readings of pressure under prolonged exposure to high temperatures and radiation has been developed by the Callery Chemical Co. It is available in standard and special pressure ranges. It operates on alternating current from 60 to 400 cycles in continuous radiation flux of one million Roentgens per hour. The gage may be installed on any pipe or vessel for use with high temperature liquids or gases. The gage operates by measuring the change in electrical output in the secondary of the differential transformer caused by movement of the core. The core is connected by a direct linkage to the bellows. Any change in pressure on the bellows causes a directly proportional movement of the core, which, in turn induces a variation in the electrical output of the transformer.
For further information circle No. 857 on literature request card, page 32-B.

Specimen Polishing

New polishers with infinitely variable speed between 100 and 1200 rpm.

The Really NEW IDEA
In Billet Shears . . .
Now Proven In Service
HILL ACME BAR BILLET SHEAR
GET THE FACTS—SEE ONE IN OPERATION



4½" size

- Simplicity of Design.
  Clean, square cuts.
  Low maintenance.
- You'll be amazed at it's performance.
  You'll be surprised at the price.
- Made in 3", 4½", 6½" sizes and larger.
  Choice of hand, semi-automatic or
  fully automatic feed.

Full details and specifications are given in Bulletin MP-56.

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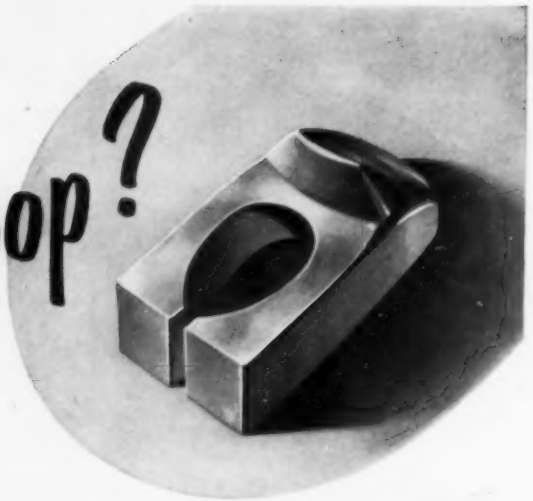
"HILL" GRINDING & POLISHING MACHINES • HYDRAULIC SURFACE GRINDERS • ALSO MANUFACTURERS OF "ACME" FORGING • THREADING TAPPING MACHINES • "CANTON" ALLIGATOR SHEARS • BILLET SHEARS • PORTABLE FLOOR CRANES • "CLEVELAND" KNIVES • SHEAR BLADES

what's the scoop?



it's SEYMOUR NICKEL SILVER *of course!*

Take a close look at one of the "scoops" — or hooks — in the slide fasteners which play a key role in your daily living.

The *best* slide fastener scoops are made of Seymour Nickel Silver flat wire. They are formed on high speed machines that produce up to 300,000,000 of these tiny parts every day. Yet, so precise is the operation that tolerances are held to half-thousandths of an inch!

Because its uniform composition and temper enable it to undergo precise forming on high speed machines, Seymour Nickel Silver meets these requirements perfectly. It will not discolor materials — it is long wearing and corrosion resistant — it has the necessary eye appeal. Best of all, it has the *natural lubricity* which makes fasteners work smoothly and without sticking. These enviable qualities have helped make Seymour the leading supplier of nickel silver wire for the slide fastener industry.

Beyond that, Seymour's readiness to produce nickel silver alloys in strict conformity to users' needs has prompted many manufacturers to say . . . "SPECIFY SEYMOUR — You KNOW it's good!"

SEYMOUR

THE SEYMOUR MANUFACTURING COMPANY

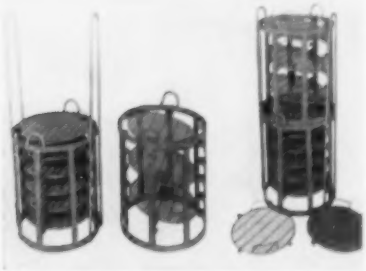
10 Franklin Street, Seymour, Connecticut

for preparing metallurgical specimens have been announced by Buehler, Ltd. The variable speed is obtained by turning a knob on the front of the machine while the motor is running. In the table models, the speed is indicated on an illuminated screen on the table top. Polishers are offered with wheels of 8, 12 or 16 in. diameter, and are available in one, two or three unit tables.

For further information circle No. 858 on literature request card, page 32-B.

Heat Treating Basket

A new heat treating retort basket holding tools of all sizes and eliminating the danger of their falling through the grid while being processed in pit-type furnaces has been announced by the Wiretex Mfg. Co. The frame is made of Type 330 stainless. Mesh



openings for each Inconel grill are spaced differently to allow tools of various sizes to be placed on separate wire shelves for perfect holding in between the mesh openings. Grills may be slanted or placed horizontally. The fixture carrier measures 15⅛ in. in diameter by 36 in. deep.

For further information circle No. 859 on literature request card, page 32-B.

Transducers

Stainless steel enclosed, oil-filled magnetostrictive transducers for immersed operation for continuous use at high power have been announced by Harris Transducer. In applications such as metal cleaning, electroplating, electropolishing, pickling and descaling, transducers or arrays of transducers can be installed directly in existing equipment. Two types are available, one operating at a frequency of 20 kc. with a power input of 250 to 400 watts per unit and the other operating at a frequency of 10 kc., with a power input of 250 to 400 watts per unit.

For further information circle No. 860 on literature request card, page 32-B.

Blast Cleaning

A new automatic, pressure blast unit for the wet blast finishing of jet engine compressor blades has been announced by the Cro-Plate Co. This unit finishes both sides of the airfoil section at the rate of about 200 per hr., removing heat treat scale and discoloration without stock removal or distortion. The unit incorporates a rinse facility for the removal of abrasive compound after blasting.

For further information circle No. 861 on literature request card, page 32-B.

Selector Switch

A new selector switch for applying power to multi-furnace, high frequency induction melting installations has been announced by Inductotherm Corp. One selector switch is required for each furnace. These switches are mounted in the lower front section of

the control panel and are water-cooled to handle high currents. To prevent opening under load, they are interlocked with the controls. Many switches can be installed on one panel permitting several to be powered from one generator. Flexibility of operations results from being able to shift power back and forth from furnace to furnace to maintain heat or melt down.

For further information circle No. 862 on literature request card, page 32-B.

Step UP
with
Gardsman
MODEL
JP SERIES
PROPORTIONING
TEMPERATURE
CONTROLLER

CONSISTENT
ACCURACY!

This *tube-free* instrument brings many advantages over *any* on-off controller. *Anticipates* temperature change, tends to stabilize at *closer* tolerance. Cuts rejects, maintenance; ends adjustment, tube-replacement. Reliability *Guaranteed.* Write for Bulletin JP-1.

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SALES OFFICES IN PRINCIPAL CITIES

FORD MOTOR COMPANY Paints a Rainbow...

A technique in spraying developed by the Ford Motor Company results in exciting rainbow pastels . . . plus new speed in paint application . . . faster color changeover . . . and superb quality of finish.

DESPATCH built and installed the Down Draft Spray Booth shown above in Ford's Dearborn plant. Wealth of production experience assures the highest standard of performance from DESPATCH equipment. There's a DESPATCH-trained resident engineer near you. Why not talk to him about your finishing requirements?

Photo of interior of DESPATCH spray booth shows down draft air flow. Notice the wide working area around the production line.

Write for NEW Bulletin 51

Just off the presses! . . . 16 colorful pages of suggestions, tips and ideas on modern ways to achieve better finishes, faster production and smoother handling of metal products . . . at lower cost.

DESPATCH OVEN COMPANY

Minneapolis Office—619 S. E. 8th St.

Sales and Service in All 26 Principal Cities

PIONEERS IN ENGINEERING FINISHING SYSTEMS FOR INDUSTRY

APPLICATION and EQUIPMENT new literature

865. Adhesives
Data chart gives form, percent solids, viscosity, time and curing temperature for line of adhesives. *Rubber and Asbestos Corp.*

866. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

867. Alloy Steel
207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

868. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

869. Aluminum Alloy
Bulletin 103 on high strength aluminum alloy which ages at room temperature. *Federated Metals Div.*

870. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

871. Ammonia for Heat Treat
Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". *Armour*

872. Atmosphere Furnace
Bulletin on controlled atmosphere, continuous rotary retort furnace describes operation and construction. *American Gas Furnace*

873. Atmosphere Furnace
12-page bulletin 1054 on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

874. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

875. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

876. Bearings
20 data sheets give special properties and case histories for new Rulon oil-free bearing material. *Dixon Corp.*

877. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses. *W. M. Chace*

878. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

879. Blast Cleaning
24-page catalog 1210 on equipment and accessories for blast cleaning and dust control. *Pangborn*

880. Boron
16-page book on boron carbide, elemental boron and other boron-rich materials. Property data, sizing of powders, manufacture, uses. *Norton*

881. Boron Additive
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

882. Brazing
8-page bulletin S-1050 on production brazing and soldering. Automatic brazing machine. *Selas Corp.*

883. Brazing Aluminum
12-page bulletin, ADR 45, on how to torch braze aluminum and strength of joints so brazed. *Air Reduction Sales*

884. Bright Hardening
Article on commercial bright hardening of stainless steel in Heat Treat Review, Vol. 6, No. 3. *Surface Combustion*

885. Bronze
Folder gives tables of properties, uses, forms and other data on phosphor bronzes. *Chase Brass & Copper Co.*

886. Bulb Thermometers
44-page catalog covers selection data, recorders and indicators, controls, psychrometers, bulbs, tubing and fittings. *Minneapolis-Honeywell*

887. Burner
New bulletin 214 on dual-fuel burner gives design of burner, its capacity. *North American Mfg.*

888. Calibrating Machine
Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

889. Carbides
84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

890. Carbon Brick
Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

891. Carbon Control
12-page catalog TD4-620 (2) on Microcarb atmosphere control for carbon potential in Homocarb furnaces. *Leeds & Northrup*

892. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

893. Carbonitriding
28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

894. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

895. Castings
New 4-page bulletin on new process for making steel castings from ceramic molds. *Lebanon Steel Foundry*

896. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

897. Centrifugal Castings
Folder on advantages of centrifugally cast thermalloy. *Electro-Alloys Div.*

898. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

899. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

900. Comparator
Bulletin on electric comparator for external measurements of gage blocks to production parts. *Metron Instrument Co.*

864. Precision Casting
This booklet describes a new molding material for increasing production of precision casting. Its 20 pages illustrate with photos and drawings the steps involved in making the pattern, the dense plaster model, the porous plaster mold, the glascast mold and the casting. A typical set-up for producing 500 castings a day is outlined. *Corning Glass Works*

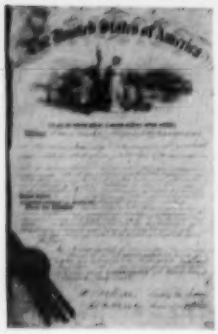
901. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

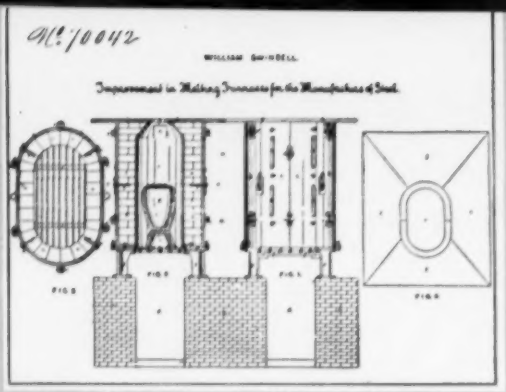
902. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

903. Copper Alloys
48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

904. Copper Alloys
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

905. Corrosion of Copper
28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tab-





An early patent (No. 70,042 U.S. Patent Office) granted to Mr. William Swindell for an improved crucible furnace, for the melting of steel.

OVER 105 YEARS
... of knowing how

Today's SWINDELL Electric Melting Furnaces, employing the most advanced construction and operating features, reflect in their performance a continuity of steel-melting knowledge and experience extending over 105 years. In fact, a very large American steel producer has been our customer for 103 years. • *Knowing how* is one of the two great qualities in SWINDELL furnace production. The other is integrity. • Let us consult with you.

SWINDELL

ELECTRIC MELTING FURNACES

SWINDELL-DRESSLER CORP.
DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES
Pittsburgh, Pa.

ulation of their relative corrosion resistance. *American Brass*

906. Cutting Machine
Folder on universal power cutter for plate and sheet metal working. *Nord Corp.*

907. Cutting Oil
Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

908. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

909. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

910. Degreaser
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

911. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

912. Die Casting Machines
New illustrated brochure gives special features and illustrates various die casting installations and parts which can be run. *Lester Phoenix*

913. Die Castings
Folder on pressure die castings of brass describes how they are made. *Titan Metal*

914. Die Steel
Bulletins on air-hardening, high-carbon, high-chromium die steel containing sulphide additives. *Latrobe*

915. Dryer
New Bulletin 130 describes Aero after cooler for removing moisture from compressed air and gas. Application of equipment to air liquefaction systems. *Niagara Blower Co.*

916. Dust Control
24-page bulletins 98 on dust control describes and diagrams systems and their operation, gives capacities of filters and kinds of dust which may be controlled. *W. W. Sly Mfg. Co.*

917. Dynamometers
4-page folder on precision dynamometers for measuring traction, tension or weight. Capacities from 0 to 500 lb. to 0 to 100,000 lb. *W. C. Dillon*

918. Electric Furnaces
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

919. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

920. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

921. Electron Microscope
20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

922. Electronic Gages
12-page bulletin on electronic equipment for dimensional inspection and control applications. *Cleveland Instrument*

923. Electron Tubes
Folder on tubes for industry, research and other applications. Separate data sheets give description, operating conditions, constant current characteristics. *Machlett Laboratories*

924. Electroplating
Chart gives reference data for gold, rhodium, palladium, platinum, silver, nickel plating. *Technic, Inc.*

925. Extrusion
Folder describes the hot extrusion process and gives its history. *Jones & Laughlin*

926. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

927. Finishing
16-page Bulletin 51 on handling, metal cleaning, precision finishing and baking equipment. *Despatch Oven*

928. Finishing
Catalog A-654 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

929. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

930. Flaw Detection
Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

931. Flaw Location
12-page booklet on dye penetrant inspection method. Suggestions on how to perform inspection by this method. *Turco Products, Inc.*

932. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

933. Forgings
New bulletin on forge steel making, open die forging, machining, heat treating and finishing. *National Forge*

934. Forging Hammers
24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

935. Forgings
Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

936. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

937. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

938. Formed Shapes
New 26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

939. Forming
86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. *Yoder*

940. Furnace Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

941. Furnace Belts
New 42-page booklet on alloy steel belts for continuous high-temperature furnaces. Belt selection guide. *Wickwire Spencer Steel Div.*

942. Furnace Controls
44-page condensed catalog of controls for industrial furnaces and ovens. *Minneapolis-Honeywell Regulator Co.*

943. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

944. Furnaces
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

945. Furnaces
32-page catalog of industrial equipment includes furnaces and furnace accessories, special valves, mechanical equipment, materials handling equipment. *Salem-Brosius*

946. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

947. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

948. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

949. Furnaces, Annealing
Folder of performance and cost data on radiant tube and roller hearth furnaces. *Gas Machinery*

950. Furnace Fixtures
Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. *Fahralloy*

951. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

952. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

953. Gamma Ray Sources
24-page booklet on portable gamma ray projectors, using cobalt 60, cesium 137, iridium 192. Operation and construction features. *Metal & Thermit Corp.*

954. Gas Analysis
New Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. *Burrell*

955. Gas Carburizing
8-page booklet on furnace equipment for gas carburizing. Continuous and batch processes. *Surface Combustion*

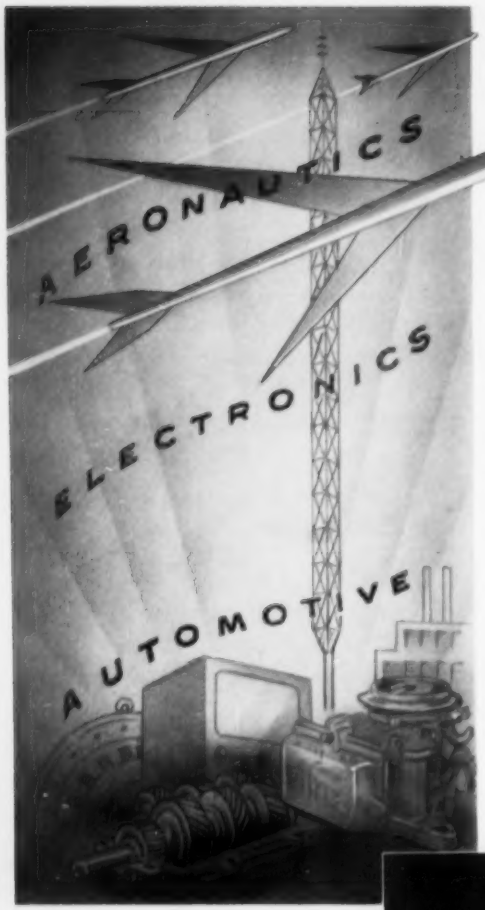
956. Globar Furnaces
Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

957. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

958. Graphite Molds
Data on two types of molds for casting magnesium, steel, copper, brass and other metals. *National Carbon*

959. Graphitic Tool Steel
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

960. Hard Surfacing
40-page hard facing manual tells what metals can be hard faced, how to select right hard facing material, lists step-by-step procedures and industrial applications. *Haynes Stellite*



Announcing..

"SUPERCASE"

OUR NEW PROCESS for NITRIDING STAINLESS STEEL

"SUPERCASE" is especially adaptable for use on parts where an extremely hard, wear resistant surface with maximum corrosion resistance is needed.

"SUPERCASE" has already been successfully proven in use by *Electronics, Aircraft, Carburetor, Transmission and Small Parts* manufacturers.

"SUPERCASING" is rapidly being adopted by manufacturers in many other fields of industry.

Advantages of "SUPERCASE" Over Older Nitriding Methods

1. **"SUPERCASE"** depths are controlled to closer limits. A uniform, extremely hard case, **approaching the hardness of a diamond,** is obtained by this process with only a light case required. Normal case depth ranges between .0003 to .0007, yet wear tests on **"SUPERCASED"** gears prove they outlasted, **by several times,** the life of the unit to be used.

2. **"SUPERCASE"** may be removed in the event of a change after parts have been finished – the parts re-worked and then re-nitrided.

3. **"SUPERCASE"** may be done on a selective basis. To machine an area further after nitriding, area can be masked off and will remain soft after processing.

4. **"SUPERCASE"** can be used on all types of Stainless Steel.

ADVANTAGES of "SUPERCASE"

CLOSER LIMITS

Very Light Case required.

•

REWORKING

Case can be removed, parts reworked and re-nitrided.

•

SELECTIVE BASIS

Small areas may be masked to remain soft after nitriding.

•

VARIETY

"SUPERCASE" may be used on all stainless steels.

Typical "SUPERCASED" Parts

We Maintain a Complete Metallurgical Department as a Service and Courtesy for Our Customers

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961. Hardness Conversion Tables
Celluloid card, 2¾ x 4¾ in., gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels. *International Nickel*

962. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

963. Hardness Tester
Bulletin on hardness tester for all regular and superficial Rockwell tests. *Kent Cliff Div., Torsion Balance Co.*

964. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

965. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

966. Hardness Tester
New bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

967. Hardness Tester
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

968. Hardness Testing
8-page catalog B-953 on principles and standards of Brinell hardness testing, and types of machines. *Steel City Testing Machines*

969. Heat Resistant Alloy
10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

970. Heat Treating
Catalog of complete line of heat treating furnaces and atmosphere generators, electric and fuel fired. *Sargent & Wilbur*

971. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

972. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

973. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

974. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

975. High-Alloy Castings
16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

976. High-Speed Steels
Bulletin on free machining tool steels and die steels. Descriptions, composition, heat treatment. *Vanadium-Alloys Steel*

977. High-Strength Steel
New 24-page booklet gives technical information and applications of high-strength, weldable, alloy steel. *Lukens Steel*

978. High-Strength Steel
48-page book on T-1 steel, its properties and applications. *U. S. Steel*

979. High-Strength Steels
48-page booklet on applications of seven nickel-copper high-strength low-alloy steels. *International Nickel Co.*

980. High-Tensile Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

981. Hydrogen Atmosphere
Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to −70° F. *Baker & Co.*

982. Identifying Stainless
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

983. Impact Testing
Bulletin on machine for Izod, Charpy and tension testing. *Riehle*

984. Induction Heating
New bulletin on remote heating station for motor generator induction heating equipment. *Lindberg Engineering Co.*

985. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

986. Induction Heating
24-page booklet on low-frequency induction heating used for preheating and normalizing for welding and other industrial applications. *Electric Arc, Inc.*

987. Induction Heating
Bulletin on heat treating, joining and hot forming. Charts on current penetration and equipment for heating steel above curie point. *Magnethermic Corp.*

988. Induction Heating
36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

989. Industrial Heating
20-page handbook classifies industrial ovens and gives pointers on oven selection. *Michigan Oven Co.*

990. Infrared Analyzer
4-page data sheet on infrared gas analyzer describes instrument, its operation and maintenance. *Leeds & Northrup*

991. Instruments
32-page bulletin 427-1 on electronic indicators, recorders and controllers, of the electrical bridge, self-balancing type. *Foxboro*

992. Insulation
40-page industrial products catalog on insulations, refractory products and others. *Johns-Manville*

993. Investment Casting
New 8-page bulletin on wax injection presses for investment casting. *Alexander Saunders*

994. Ion Exchange
6-page reprint on treatment of certain plating solutions by ion exchange. *National Aluminate Corp.*

995. Iron Powders
12-page bulletin No. 2 on how electrolytic and reduced iron powders are made. Parts made, uses. *Plastic Metals Division, U. S. Radiator Corp.*

996. Joining Magnesium
126-page book on welding, adhesive bonding and mechanical joining of magnesium. *Dow Chemical*

997. Laboratory Equipment
Bulletins on three Stanton balances and a thermo recording balance. *Burrell*

998. Laboratory Furnace
Bulletin RT-10 on 25 lb. per hr. laboratory metal treating unit for carburizing, hardening, carbonitriding, brazing, carbon restoration. *Ipsen*

999. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

1000. Leaded Steel
8-page bulletin gives chemical composition, mechanical properties and case studies showing machining production rates of Ledloy, lead bearing steel. *Ryerson*

1001. Liquid Honing
News letter, V. 4, No. 3, explains application of hard chromium plating to machine tools and assistance of liquid honing in producing a good finish. *City Plating Works*

1002. Low-Carbon Stainless
"Melting Low-Carbon Stainless Steel" shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

1003. Low-Temperature Brazing
Folder on brazing copper to nichrome, stellite to steel, brass to brass, steel to cast iron. *Handy & Harman*

1004. Lubricant
Bulletin 425 on colloidal dispersions for use in metal casting. Best formulas for achieving high lubricity and wetting action. *Acheson Colloids*

1005. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

1006. Lubrication
New brochure B-3 on solid film lubrication gives results of laboratory and research tests. *Electrofilm, Inc.*

1007. Machining Copper
12-page bulletin on machining properties, practices, feeds, speeds, tool design. *Ampco*

1008. Machining Magnesium
64-page book discusses the various machining operations, machinability, coolants for magnesium. *Dow Chemical*

1009. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1010. Magnesium Alloys
Loose-leaf folder of data and tables on chemical specifications, properties, extrusion, machining operations. *Brooks and Perkins*

1011. Marking Dies
New 26-page handbook on marking with steel dies. Use and selection of steel dies for every application. Stamping, embossing, foil leaf marking dies. Holders. *Jas. H. Matthews*

1012. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

1013. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1014. Mixers
Catalog on full line of mixers for quenching operations. *Alsop Eng.*

1015. Moisture Measurement
12-page bulletin on how to measure water vapor in air and other gases. Gravometric, dew point and wet and dry

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bulb methods, and others. *Pittsburgh Lectrodryer*

1016. Molybdenum

72-page book gives data on unalloyed molybdenum and four arc-cast alloys. Several pages of references. *Climax Molybdenum*

1017. Nickel Plating

20-page instruction manual on bright nickel plating by the nickel-lume process. Bath preparation, converting existing baths, solution maintenance and purification. *Hanson-Van Winkle-Munning*

1018. Nitrogen Generator

New 6-page bulletin No. I-100 gives flow diagram and explains operation. *C. M. Kemp Mfg. Co.*

1019. Nondestructive Inspection

8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection and its uses. *Sperry Products*

1020. Nondestructive Testing

8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1021. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

1022. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1023. Optical Pyrometer

Catalog No. 85 on optical pyrometer which is direct reading. Method of operation, maintenance. *Pyrometer Instrument*

1024. Ovens

Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° F. *Young Brothers*

1025. Ovens

16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl-Mayer*

1026. Paint Stripping

Folder on steam gun method, hot flow method, cold spray method, tank method. *Oakite*

1027. Phase Contrast

16-page Bulletin D-104 on theory, applications and equipment for phase contrast microscopy. *Bausch & Lomb*

1028. Photomicrography

Catalog E-210 on sliding base, high or low power photomicrographic equipment. *Bausch & Lomb*

1029. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1030. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1031. Polishing Materials

20-page booklet includes samples of emery, aluminum oxide and silicon carbide papers and 12 polishing cloths. *Buehler, Ltd.*

1032. Portable Recorder

Bulletin 60-100 on instrument for recording any measurement that can be converted to a change in resistance of d.c. millivoltage. *Thermo Electric*

1033. Post-Weld Heat Treatment

8-page bulletin TR-543 demonstrates the need for post-weld heat treatment of air hardening alloys. *Babcock & Wilcox*

1034. Potentiometers

Article gives technical data on semi-precision potentiometers. *Rubicon*

1035. Powder Metallurgy

12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever Co.*

1036. Powdered Metals

Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc*

1037. Precision Castings

New 5-page folder on investment casting. *Engineered Precision Casting*

1038. Precision Casting

12-page book on alloy selection and design for precision casting. *Arwood Precision Casting*

1039. Pure Metals

Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

1040. Pyrometers

12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1041. Quench Agitation

32-page booklet on 1 to 500 hp. mixers, construction, operation, applications. *Mixing Equipment Co.*

1042. Quenching

64-page book tells what happens when steel is heated and cooled, describes quenching media, quenching practices, interrupted quenching and cooling methods. *E. F. Houghton*

1043. Quenching Oil

10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

1044. Quenching Oil

8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

1045. Recorders

New 12-page bulletin contains methods of applying 6-in. strip-chart recorders for pressure, liquid level, temperature, flow, mechanical motion. *Bristol*

1046. Recorders and Controllers

Bulletin 7202 on vertical scale indicator. Miniature instrument to measure and control process variables. *Minneapolis-Honeywell*

1047. Refractories

32-page catalog on range of refractory products for steel mills, electric furnaces, melting, ladles, and other industrial uses. *Plibrico Company*

1048. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

1049. Refractory Coating

Data on aluminum oxide and silicon carbide coating which may be sprayed on. *Norton Co.*

1050. Residual Stresses

32-page, pocket-size booklet on residual stresses in cold-finished steel bars and their effect on manufactured parts. *La Salle Steel*

1051. Resistance Welding

24-page catalog on equipment for resistance welding includes reference tables and property and application charts. *Ampco*

(Continued on page 32-A)

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CLEVELAND Jim Skarda CHerry 1-9174

DAYTON, OHIO Herb Davis Call Detroit WAlnut 1-4462

BRIDGEPORT John Parky CLearwater 9-9814

HOUSTON K. E. Luger Co. JAckson 9-5581

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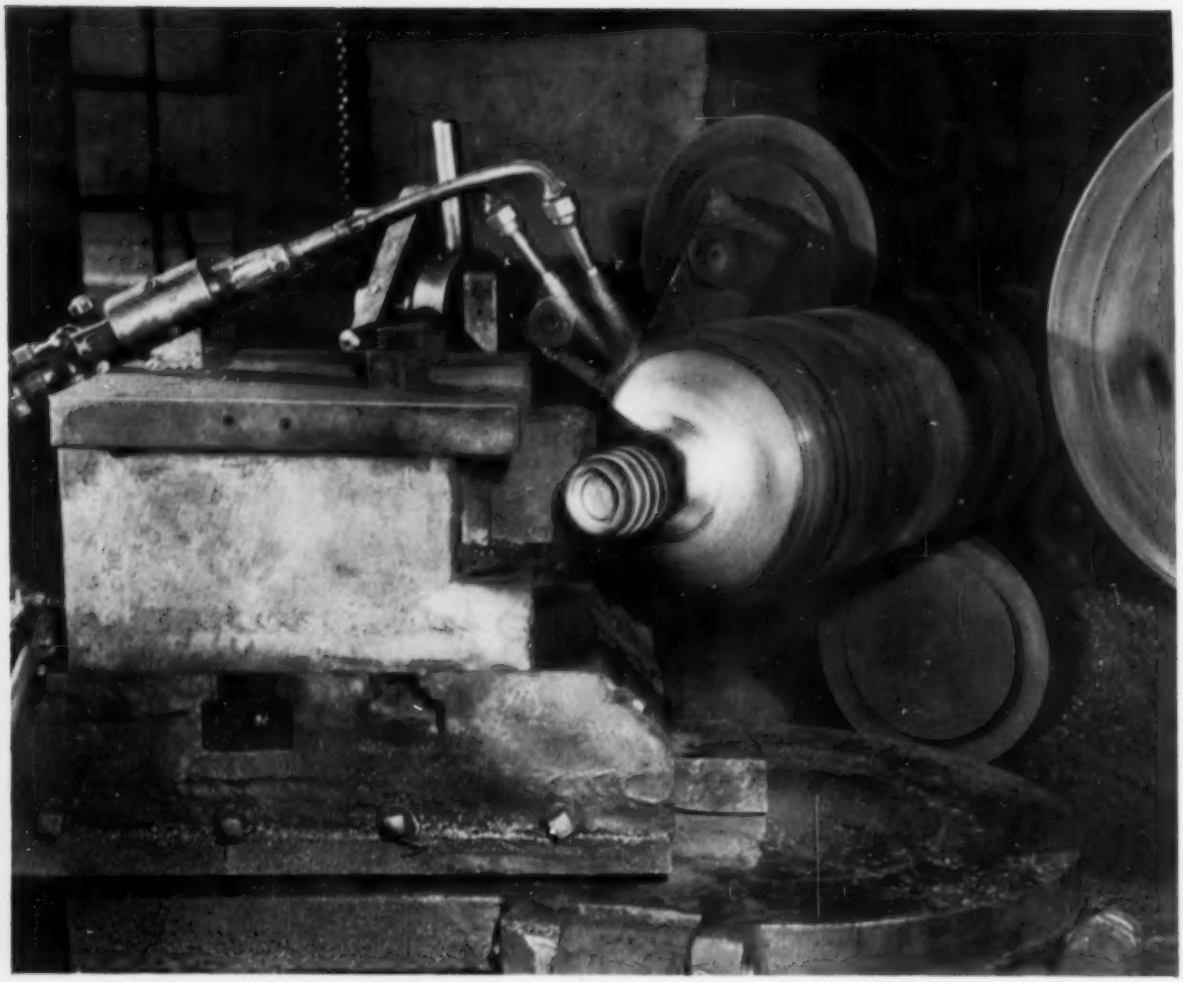

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The Marison Company of South Elgin, Ill., is a leading producer of industrial oxygen cylinders manufactured to hold this active gas at 2400 psi. From its beginning, Marison has consistently used Seamless Tubing for this task.

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Whatever your requirements in tubing...for consistently high and uniform quality...for top service ...look to B&W. For more information on selection and use of carbon, alloy or stainless steel tubing, write for Bulletin 361 or call in Mr. Tubes, your nearby B&W Tube Representative. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-5075P

Seamless and welded tubular products, seamless welding fittings and flanges—in carbon, alloy and stainless steels

(Continued from page 31)

1052. Rhodium Plating
Data on properties, thickness quired, costs, operation, appli *Technic*

1053. Rust Preventives
12-page bulletin on water-solub preventive. *Production Specialties*

1054. Rust Removal
Folder on new alkaline cleanin rial for removal of rust, certain t heat scale and metallic smuts. *Oak*

1055. Salt Bath Furnace
Data on salt bath furnaces for ba conveyorized work. *Upton*

1056. Salt Baths
28-page book deals with heat tre carburizing, bath maintenance, safe cautions. *American Cyanamid*

1057. Saws
Catalog C-53 describes 35 mo metal-cutting saws. *Armstrong-Bl*

1058. Selective Carburiz
Bulletin on "No-Carb" for selecti burizing and prevention of decarb on high alloy steels during heat hardening. *Park Chemical*

1059. Shear
Bulletin on bar and billet she rounds, squares, flats, billets and turals, either hot or cold. *Hill Ac*

1060. Shell Molding
New 12-page brochure describe duction and advantages of shellcas ucts. *Electric Steel Foundry Co.*

1061. Shot and Grit
Handy calculator has size data f grades of shot and grit. *Pangborn*

1062. Shotblasting
16-page "Primer on the Use of S Grit". Problems of blast cleaning tions. *Hickman, Williams*

1063. Sintered Carbides
New 24-page booklet on the cha istics of the various grades, for r and design engineers. *Kennametal*

1064. Sodium
28-page booklet on using sodium persed form tells how dispersions a pared and handled, and their adva *Ethyl Corp.*

1065. Soldering
Quick reference chart to melting of all solder alloys. *Anchor Metal*

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Overshoot eliminated, draw furnace control improved by Model 405 Capacitrol

Precision temperature control sold management on Wheelco Model 405 Capacitrols at General Heat Treating Co., Chicago. Elimination of heat variations and overshoot caused by on-off control meant a significant improvement in product quality.

These instruments control batch-type furnaces that draw screws, springs, nuts, and miscellaneous parts, in loads ranging from 600 to 1100 lb. The furnaces are completely Wheelco-equipped — a Capacilog records operating temperatures and the combustion safeguard system consists of a Series 1300 Flame-otrol with flame rod sensing element. You can improve *any* process heating operation with the smooth, accurate control possible with Model 405 proportioning Capacitrols.

Your Wheelco field engineer will be glad to help solve your process heating problems. Call him *today!*

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Industrial Instruments • Automatic Controls • Air Distribution Products
Aircraft Controls • Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

(Continued from page 31)

1052. Rhodium Plating
Data on properties, thicknesses required, costs, operation, applications. *Technic*

1053. Rust Preventives
12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1054. Rust Removal
Folder on new alkaline cleaning material for removal of rust, certain types of heat scale and metallic smuts. *Oakite*

1055. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

1056. Salt Baths
28-page book deals with heat treatment, carburizing, bath maintenance, safety precautions. *American Cyanamid*

1057. Saws
Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1058. Selective Carburizer
Bulletin on "No-Carb" for selective carburizing and prevention of decarburizing on high alloy steels during heating for hardening. *Park Chemical*

1059. Shear
Bulletin on bar and billet shear for rounds, squares, flats, billets and structurals, either hot or cold. *Hill Acme Co.*

1060. Shell Molding
New 12-page brochure describes production and advantages of shellcast products. *Electric Steel Foundry Co.*

1061. Shot and Grit
Handy calculator has size data for SAE grades of shot and grit. *Pangborn*

1062. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

1063. Sintered Carbides
New 24-page booklet on the characteristics of the various grades, for research and design engineers. *Kennametal*

1064. Sodium
28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

1065. Soldering
Quick reference chart to melting points of all solder alloys. *Anchor Metal*

1066. Spark Testing
20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

1067. Spectrochemical Analysis
News Letter on instruments for direct reading analysis describes the basic unit, excitation unit, electronic section, photographing arrangements, maintenance and performance. *Jarrell-Ash Co.*

1068. Spectrographic Supplies
24-page catalog on special pure materials and alloy standards, plates and films, graphite electrodes and powders. *Jarrell-Ash*

1069. Stainless Castings
Bulletin on advantages of corrosion-resistant castings. *Ohio Steel Foundry*

1070. Stainless Electrodes
16-page data bulletin on selection of proper grades of welding rod for each grade of stainless steel. *Crucible Steel*

1071. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

1072. Stainless Steel
44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

1073. Stainless Strip
32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel Corp.*

1074. Stainless Tubing
40-page catalog, section 20, on alloys used, fabrication and working, pickling process. Sections on welding, soldering, brazing, machinability of heat resisting steels. *Superior Tube Co.*

1075. Stampings
16-page brochure on story of stamping. Handy tabular data. *Republic Steel*

1076. Steel
16-page booklet on special steels for industry includes stainless, electrical, silicon, and tool steels, magnetic materials, carbide metals. *Allegheny Ludlum Steel*

1077. Steel 52100
New stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

1078. Steelmaking
Brochure on modern openhearth design and construction. *Loftus*

1079. Steels
New 102-page edition of catalog of alloy and stainless steels gives technical data on alloys, alloys for use in various industries, company's products in each alloy. *Electric Steel Foundry Co.*

1080. Stress-Strain Recorders
28-page bulletin No. 4215 on 16 standard recorders and 50 models of strain followers, for use on standard testing machines. *Baldwin-Lima-Hamilton*

1081. Sub-Zero Equipment
12-page catalog of chilling machines and temperature testing units. *Cincinnati Sub-Zero Products*

1082. Surface Measurement
8-page bulletin contains a description of ASA standard on surface roughness, waviness and lay. Basic definitions, how to designate these characteristics, types of roughness-height average. *Micrometrical Mfg.*

1083. Temperature Control
New 8-page bulletin on temperature control systems contains selection guide, terminology, types of control systems. *Wheelco Instrument Div.*

1084. Temperature Conversion
Chart converts degrees Fahrenheit to Centigrade and vice versa from —400 to 4000° and shows range of sensing elements. *Thermo Electric*

1085. Tempilstiks
"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

1086. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1087. Tester
Bulletin 164 on Dyhedron, dynamic diamond tester for hardness and lubricity of materials. *Taber Instrument*

1088. Testing Equipment
8-page catalog of abrasion, physical, thickness, compression and recovery testers. *Custom Scientific Instruments*

1089. Testing Instruments
16-page bulletin on portable recorders, voltmeters and ammeters, surface roughness scales and other electric testers. *General Electric*

1090. Testing Machines
Universal testing machines and equipment are diagrammed, described and illustrated in 20-page Bulletin 43. *Tinius Olsen*

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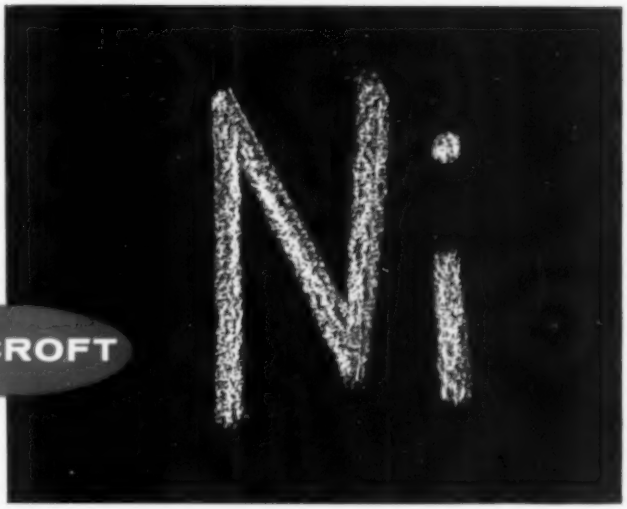

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NICKEL SHORTAGE

Today's shortage of nickel—caused by government stockpiling—has important repercussions for potential buyers of heat treat furnaces.

Heat-resistant alloys may be used in radiant tubes, rails, and other interior sections of the furnace only when nickel is readily available.

That's why we have developed a furnace to meet this challenge—*one that requires no alloys,* yet will meet all the requirements of trouble-free life, low cost, stepped-up production, and high quality control. This is just another example of Holcroft pioneering in furnace design. Better investigate —right now!

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- 1955—Developed a bantam-sized batch furnace using a minimum of alloys.
- 1954—Developed "Lo-Dew" generator for producing exothermic and endothermic atmospheres.
- 1951—Installed silicon carbide skid rails in conveyorized furnaces.

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

1091. Thermocouples
36-page Bulletin 19-10 describes various types of thermocouples, extension wire and other accessories. *Foxboro*

1092. Thermocouples
32-page file book on pyrometer accessories. Selection of thermocouple and protective tube. *West Instrument Corp.*

1093. Thickness Testers
6-page catalog on Audigage thickness testers. Characteristics and applications of five models. *Branson Instruments*

1094. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures high temperature characteristics. *Mallory-Sharon Titanium*

1095. Titanium Carbide
29-page pocket-sized book reviews methods of manufacture, properties, uses. Bibliography. *Titanium Alloy Mfg. Div.*

1096. Tool and Die Steels
28-page guide to qualities and sizes available. *Uddeholm*

1097. Tool Steel
36-page booklet on properties and applications of high speed steels, nonferrous cutting materials and carbides. *Allegheny Ludlum*

1098. Tool Steel
44-page book on tool steels for the nonmetallurgist explains the six basic kinds of tool steels and their heat treatment. *Crucible Steel*

1099. Tubing
New 8-page catalog on carbon and alloy steel tubing of mechanical, pressure, airframe and aircraft mechanical quality. *Ohio Seamless Tube*

1100. Tubing
Bulletin TB-408 on seamless or welded tubing for the process industry. Stainless, alloy or carbon steel. *Babcock & Wilcox*

1101. Tungsten
32-page book gives applications of tungsten, types of ore, mining. *Tungsten Institute*

1102. Vacuum Calculator
Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

1103. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

1104. Vacuum Metallurgy
Information memo tells of materials handling in vacuum metallurgy. *Consolidated Vacuum*

1105. Vacuum Metals
21-page report on vacuum melted metals discusses equipment, properties of metals and their applications. *Ajax Electrothermic Corp.*

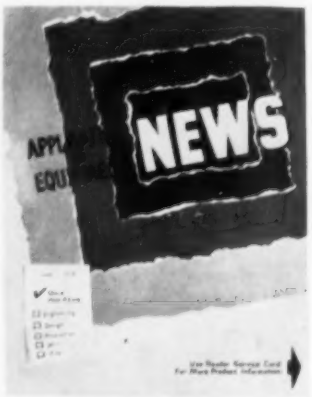
1106. Vacuum Pumps
16-page booklet on maintenance of vacuum pumps. *Stokes*

1110. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1111. Welding Repair
New 4-page booklet repair of cast iron parts by welding with Ni-Rod and Ni-Rod 55. *International Nickel*

1112. Wire Cloth
84-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

1113. Wire Drawing
New 8-page booklet on continuous wire drawing machines for brass, copper, aluminum and other nonferrous metals. *Waterbury Farrel Foundry & Machine*



863. Product File
More than 60 new product developments, more than 700 important and interesting booklets, bulletins and engineering data sheets are presented in a 32-page file reference in *Application and Equipment News*. Reprinting all the hundreds of product literature items that have appeared in Metal Progress during the first quarter of 1956, this handy summary of what's new in metals, design applications, processing, fabrication and equipment makes an ideal file reference for use throughout the year.

1107. Welding
52-page catalog on gases, welding and cutting equipment and accessories for job shops, maintenance departments and other users of light gas and arc equipment. *Air Reduction Sales*

1108. Welding
New technical data card 162A on welding stainless tubing and pipe gives information on welding characteristics of austenitic and ferritic types, methods and techniques. *Babcock & Wilcox*

1109. Welding Electrodes
84-page pocket-size booklet describes characteristics, coating, sizes of various electrodes and compares them with standard designations and other electrode brand names. *Harnischfeger*

1114. Wire Mills
12-page booklet on 2-high wire flattening mills and auxiliary equipment. *Waterbury Farrel Foundry*

1115. Wire Products
Folder on wire cloth specialties and baskets, conveyor belts and wire slings. *Cambridge Wire Cloth*

1116. X-Ray Diffraction
Bulletin 8A-3505 on film or direct recording X-ray diffraction apparatus. *X-Ray Div., General Electric*

1117. Zirconium
New 18-page pocket-sized book on manufacture, properties, metallography, machining, metal powders. Extensive bibliography. *Titanium Alloy Mfg. Div.*

APRIL, 1956

837	861	885	909	933	957	981	1005	1029	1053	1077	1101
838	862	886	910	934	958	982	1006	1030	1054	1078	1102
839	863	887	911	935	959	983	1007	1031	1055	1079	1103
840	864	888	912	936	960	984	1008	1032	1056	1080	1104
841	865	889	913	937	961	985	1009	1033	1057	1081	1105
842	866	890	914	938	962	986	1010	1034	1058	1082	1106
843	867	891	915	939	963	987	1011	1035	1059	1083	1107
844	868	892	916	940	964	988	1012	1036	1060	1084	1108
845	869	893	917	941	965	989	1013	1037	1061	1085	1109
846	870	894	918	942	966	990	1014	1038	1062	1086	1110
847	871	895	919	943	967	991	1015	1039	1063	1087	1111
848	872	896	920	944	968	992	1016	1040	1064	1088	1112
849	873	897	921	945	969	993	1017	1041	1065	1089	1113
850	874	898	922	946	970	994	1018	1042	1066	1090	1114
851	875	899	923	947	971	995	1019	1043	1067	1091	1115
852	876	900	924	948	972	996	1020	1044	1068	1092	1116
853	877	901	925	949	973	997	1021	1045	1069	1093	1117
854	878	902	926	950	974	998	1022	1046	1070	1094	
855	879	903	927	951	975	999	1023	1047	1071	1095	
856	880	904	928	952	976	1000	1024	1048	1072	1096	
857	881	905	929	953	977	1001	1025	1049	1073	1097	
858	882	906	930	954	978	1002	1026	1050	1074	1098	
859	883	907	931	955	979	1003	1027	1051	1075	1099	
860	884	908	932	956	980	1004	1028	1052	1076	1100	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name _____

Title _____

Company _____

Address _____

City and State _____

Postcard must be mailed prior to July 1, 1956. Students should write direct to manufacturers.

Hollow Mill Maker finds

DBL-2
High Speed Steel

HARD, TOUGH and VERSATILE

The maker of these adjustable hollow mills required a steel that would give top performance in a variety of jobs—turning, tapering, facing, chamfering and trepanning. After thorough testing, Ludlum's high speed DBL-2 was selected.

DBL-2 is an improved general-purpose high speed steel. It contains tungsten, molybdenum and vanadium in such proportions that it excels 18-4-1 for most applications. DBL-2's unusual combination of high hardness with toughness, its ability to hold a fine grain over a wide hardening range, and the fact that it easily machines many diverse types of stock, made it particularly well suited for this job.

In addition to these advantages, DBL-2 can be heat treated in the same furnaces and atmospheres as 18-4-1 without fear of harmful decarburization. These DBL-2 blades were heated to 2250 F, oil quenched and drawn twice at 1025 F. After heat treatment, blades easily machined such stock as aluminum, stainless steel, carbon steel, aircraft steel, plastics, bronze, screw stock, cast iron and brass.

There is an A-L tool steel to meet your toughest requirements. Call your A-L representative or distributor today . . . or write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.*

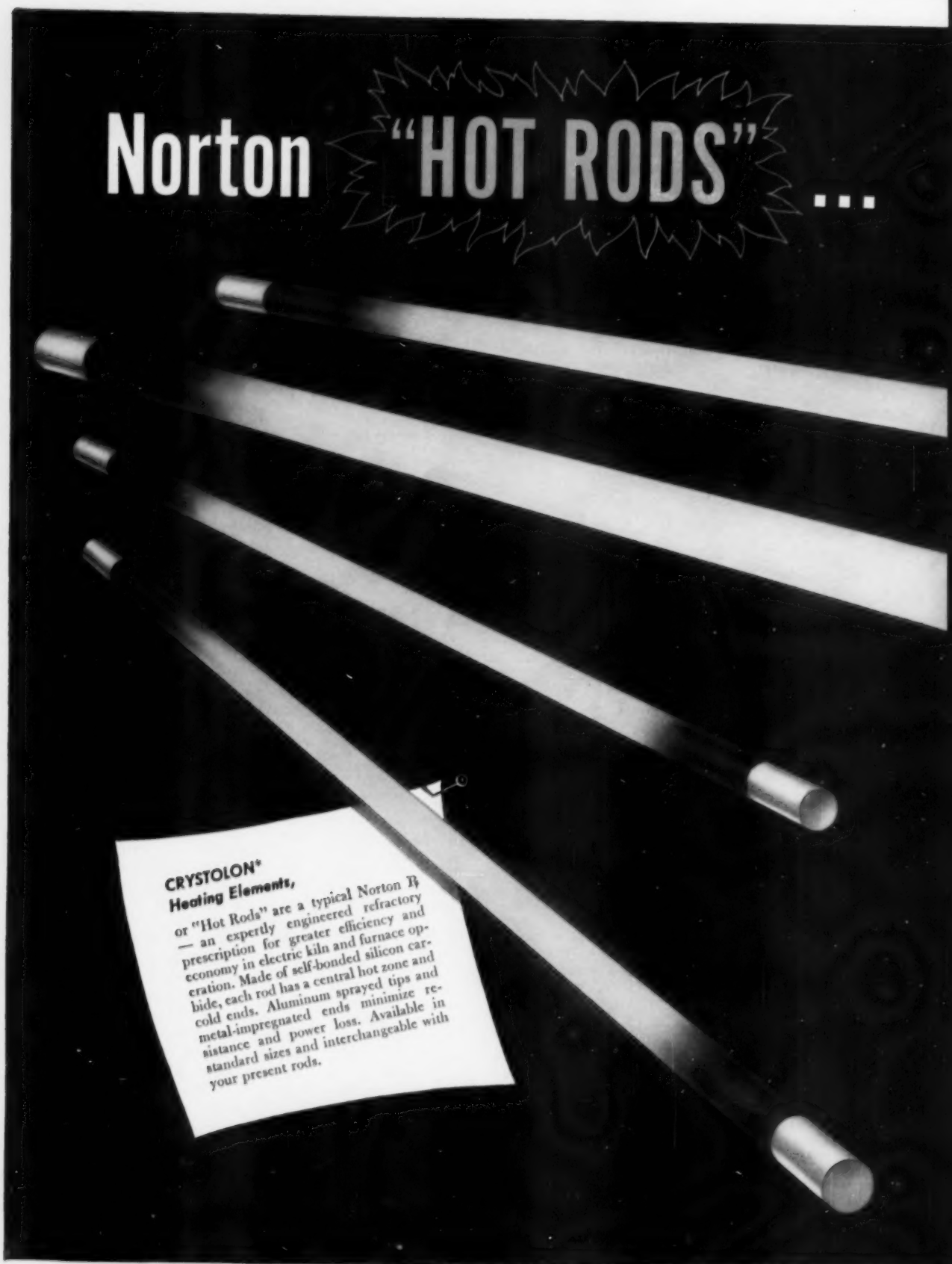
Write For Copy of
"CUTTING TOOL MATERIALS"
This 36-page illustrated booklet analyzes and compares types and covers grade selection for all major classes of cutting tools, etc., invaluable data for production men. Write for your copy today.
Address Dept. MP-76

For complete **MODERN** Tooling, call

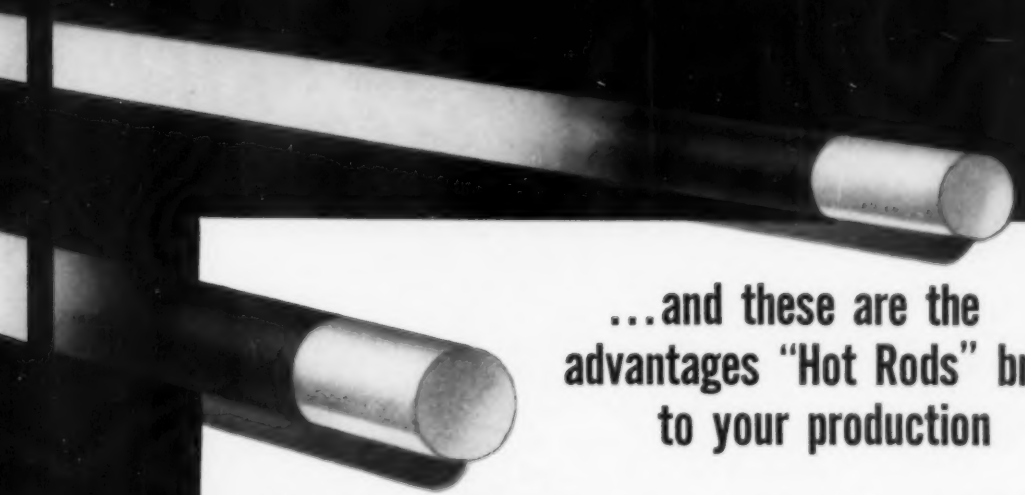
Allegheny Ludlum

WAD 5389

AL® FINE TOOL STEELS SINCE 1854


Norton "HOT RODS" ...
CRYSTOLON®
Heating Elements,
or "Hot Rods" are a typical Norton Ⅱ
— an expertly engineered refractory
prescription for greater efficiency and
economy in electric kiln and furnace op-
eration. Made of self-bonded silicon car-
bide, each rod has a central hot zone and
cold ends. Aluminum sprayed tips and
metal-impregnated ends minimize re-
sistance and power loss. Available in
standard sizes and interchangeable with
your present rods.

the heating elements that last up to three times longer!



...and these are the advantages "Hot Rods" bring to your production

Savings In Element Costs — Because you use far less of them. Many plants report "Hot Rods" outlast other nonmetallic heating elements — *up to 3 to 1!*

Lower Maintenance Costs — Using less "Hot Rods" means less time spent in replacements and voltage tap changes. And there is an additional saving. You don't have to shut down your furnace or kiln to replace elements.

Better Product Quality — "Hot Rods" heat more uniformly because of their slow, evenly matched rate of resistance increase. This helps to protect product quality and to maintain the smooth flow of production, with fewer rejects.

Fast Service — You can get "Hot Rods" on short notice, if necessary, shipped from adequate stocks. And they're packed shockproof to reach you unbroken.

Typical "Hot Rod" Applications

Brazing operations on copper, silver, etc. . . . heat treating high speed steel . . . steel hardening . . . bright annealing of stainless steels . . . bright cleaning (deoxidizing, degreasing, etc.) . . . sintering powdered metals . . . heating for forging . . . metal melting . . . ore refining.

For further facts on how "Hot Rods" can improve and reduce the cost of your own electric furnace operations, send for the booklet "Norton Heating Elements." NORTON COMPANY, Refractories Division, 323 New Bond Street, Worcester 6, Mass.

NORTON

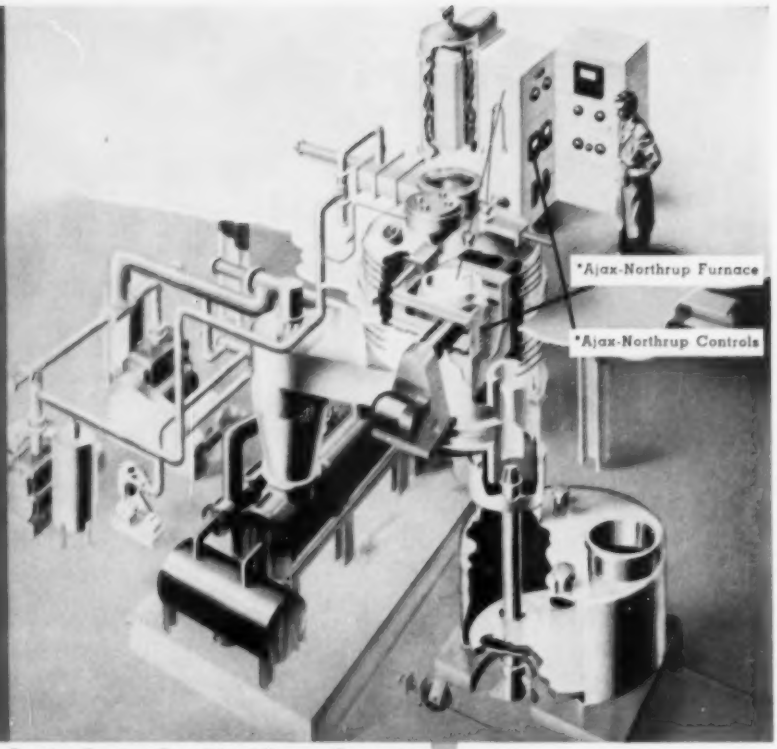
REFRACTORIES

Engineered... Rx ... Prescribed

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Making better products . . . to make your products better

nothing new here but the vacuum



Drawing Courtesy Consolidated Vacuum Corporation

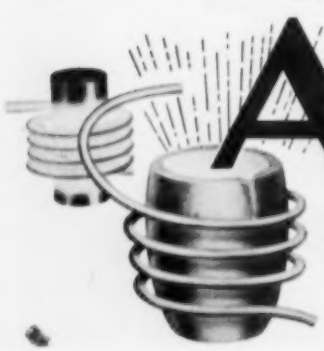
Take away the tank, a few special vacuum features and pumping equipment from this 1000 lb. capacity vacuum melting installation at the Carboloy Department of General Electric Company, and you have the same high quality AJAX-NORTHRUP furnace used for melting the finest alloys elsewhere at Carboloy and throughout the world. You can depend on AJAX-NORTHRUP furnaces for:

- *A clean melt with consistent analysis*
- *Fast, controlled melting*
- *Almost 100% recovery of scrap*
- *Amazing versatility*
- *No fumes, noise, or external heat*
- *Maximum economy and low maintenance*

*For details write AJAX ELECTROTHERMIC CORPORATION, TRENTON 5, N. J.

No induction vacuum melting installation can be any better than the high frequency induction furnace around which it is built. That's why more AJAX-NORTHRUP furnaces are used than any other for this important work.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.



AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

WATCH THAT LAST STEP!

(Quenching is the pay-off in Heat Treating)

Every step may be perfect—steel analysis, temperatures, atmospheres — but it's the *quench*, the last step in the heat treating process that makes the rest of the operation pay off.

When the quench is oil, don't take chances —use Houghto-Quench. This finest of quenching oils provides complete "wetting" of the part—no soft spots, less carry-off. No light ends to distill off under heat . . . remains stable and unchanged for years. It gives you faster quenching than any other oil . . . and this speed assures adequate hardness even for heavy sections and for steels in the low hardenability range.

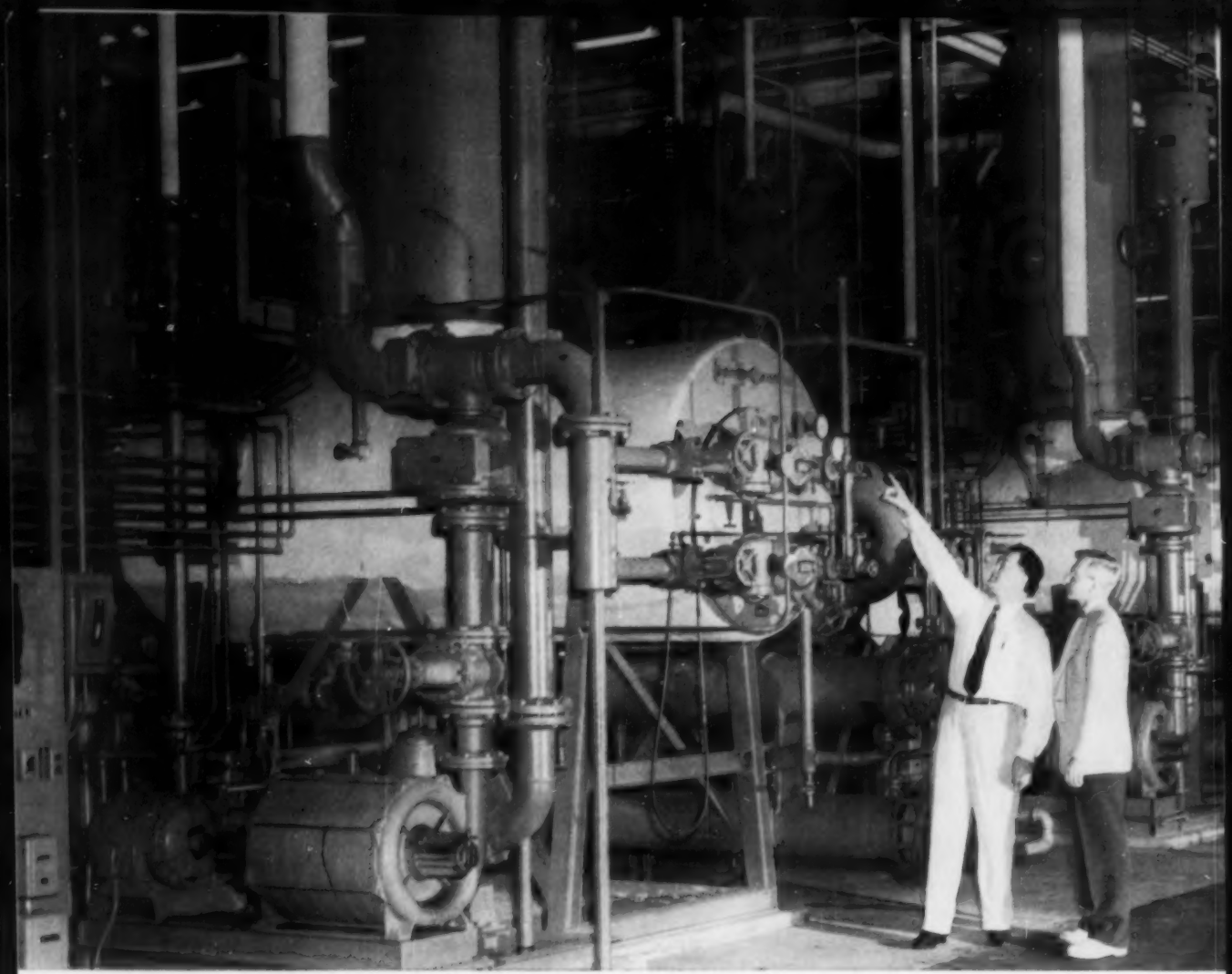
Ask the Houghton Man to show you how Houghto-Quench increases heat treating effectiveness. Write for the latest "Quenching Handbook" to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

HOUGHTO-QUENCH OILS . . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO

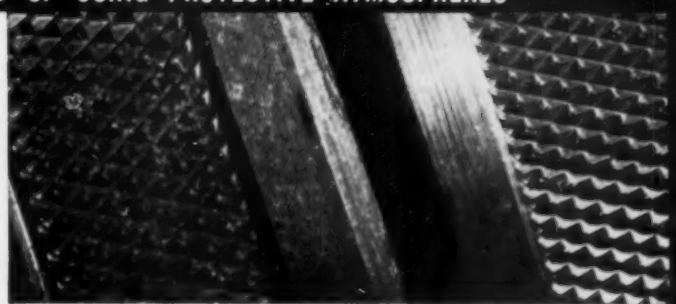
Ready to give you on-the-job service . . .



DIFFERENT COMPOSITIONS of G-E Neutralene gas are possible to fit various applications—annealing, hardening, brazing, sintering, and carburizing. G-E gas producers shown are rated at 15,000 CFH; complete line includes ratings from 200 CFH.

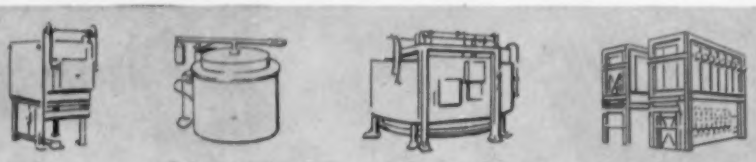
CAPSULE CASE HISTORIES SHOW BENEFITS OF USING PROTECTIVE ATMOSPHERES

OXIDES REDUCED when parts are bright annealed in Exalene gas. Pan on left is shown before cleaning; center pan, after pickling only; pan on right, after bright annealing only. Exalene gas is used also in normalizing, hardening, brazing, and sintering.

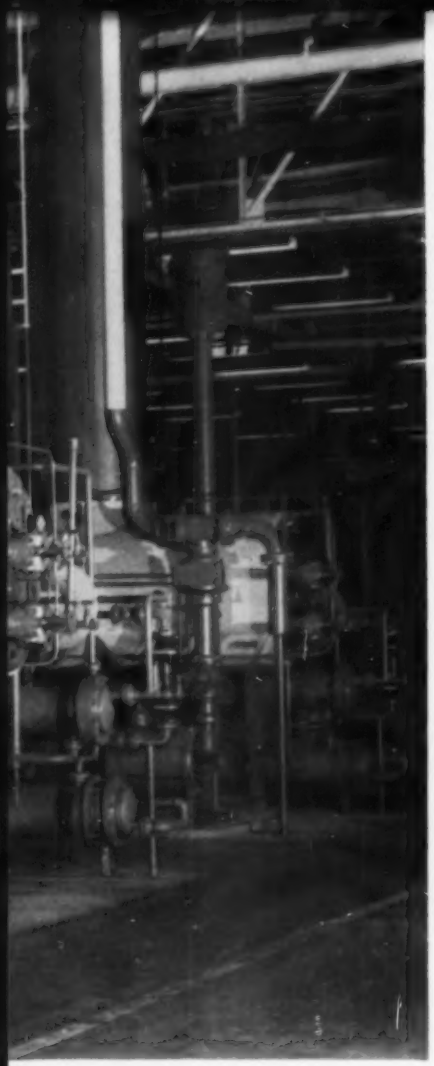


SCALE-FREE UNPITTED drill chuck on right was hardened in Thermalene atmosphere, does not need subsequent cleaning; chuck on left was hardened in air. Thermalene gas is used also in bright annealing, normalizing, brazing, sintering, and carburizing.

GENERAL ELECTRIC SELLS A COMPLETE LINE OF INDUSTRIAL FURNACES



Box | Cylindrical Pit | Rotary Hearth | Elevator



Eliminate Expensive After-work— Produce Clean Heat-treated Parts with G-E Protective Atmospheres

Protective atmospheres help you turn out heat-treated parts that are free from scale or oxides. They enable you to turn out a more salable product . . . at lower cost. This is true because pickling, grinding, machining, sandblasting, and similar operations are often made unnecessary.

General Electric offers various types and sizes of gas producers that let you manufacture atmospheres inexpensively—right in your own plant. You can prepare these atmospheres to provide exactly the right quality protection for your particular process. G-E protective atmospheres include: Exalene, an exothermic gas; Neutralene*, a CO_2-free, dry, exothermic gas; Thermalene*, an endothermic gas; Ammalene, dissociated ammonia.

Check these benefits of using protective atmospheres:

PREVENTING OXIDATION of metal surfaces during furnace heating is a primary advantage of protective atmospheres. Parts are produced at less cost and in a shorter total time cycle when scale formation is eliminated.

REDUCING OXIDES which have already formed is easily done by heating in a furnace supplied with the proper protective atmosphere. This reducing, or cleaning, is often used to prepare steel for porcelain enameling, galvanizing, or for furnace brazing.

CONTROLLING SURFACE COMPOSITION of metals in such operations as carburizing, nitriding, and prevention of decarburizing requires closely controlled furnace atmospheres.

ACCESSORY EQUIPMENT to meet specific needs is available:

Sulfur Removers take out sulfur dioxide and hydrogen sulfide where sulfur might harm the work or the furnace.

Regenerative-type Dryers remove moisture from gases. Can be had with closed-system reactivation for high-purity uses.

Refrigerated Gas Coolers remove some of the moisture from gases. These coolers may be used with regenerative-type dryers to reduce costs of preparing gases with low dew points.

COMPLETE SERVICES of your local G-E Apparatus Sales Representative include helping you to choose the most effective furnace atmosphere for your particular application . . . and to do it at lowest cost. Call him or send in coupon below for free descriptive bulletin.

*Reg. Trade-mark of General Electric Co.

GENERAL ELECTRIC

CLEANING ELIMINATED when stainless steel parts are brazed in Ammalene gas. Right-hand part is shown as it came from the brazing furnace—bright and clean.

FREE BULLETIN

Section C721-7
General Electric Company
Schenectady 5, N. Y.

Please send me a copy of your bulletin, Protective Atmospheres, GEA-5907.

NAME .....

COMPANY .....

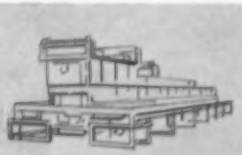
ADDRESS .....

CITY ..... STATE .....

Mesh Belt

Tower

Cylindrical Bell



Roller Hearth

Continuous Conveyor

Whatever your furnace needs for control—

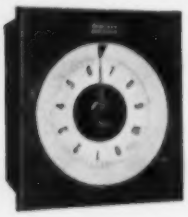
There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Note: the basic components of all *ElectroniK* models are interchangeable . . . to simplify and speed up service.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Note: all *ElectroniK* models are available in both Standard and Precision Series.

Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument... alsoavailable with pulse-type time proportioning action, in both vertical and horizontal models.

Choose the *Protect-O-Vane* Safety Cut-Off for simple, dependable excess temperature protection ... can be used with any temperature control to prevent furnace shut downs and loss of production.

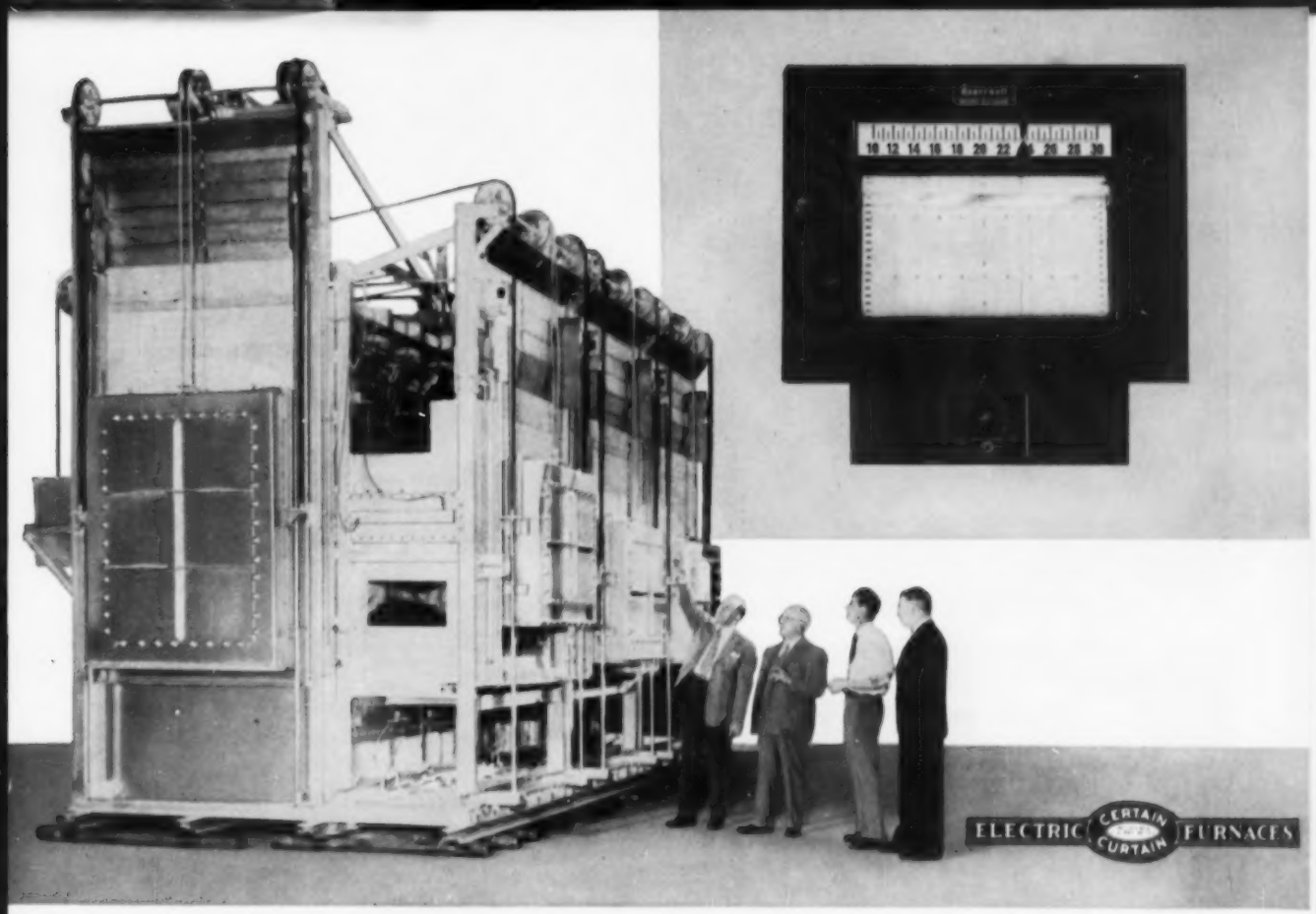
• • •

And for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

Product of the engineering skill of C. I. Hayes, Inc., of Cranston, R. I., this giant furnace has a heating chamber 19′ long, 8′ 2″ high and 4′ wide.

World's largest electric steel forging furnace

*Listed in Catalog 1531 are the varied types of **ElectroniK** Controllers . . . including electric and pneumatic systems affording a broad selection of control action. Write for your copy.*



uses *ElectroniK* instruments

SPECIALLY DESIGNED and constructed by C. I. Hayes, Inc., this mammoth furnace will heat up to 10,000 lb. billets for forging in a 50,000-ton press at Wyman-Gordon Co.

Forty-five Globar elements, with a total connected load of 600 kilowatts, supply the heat input for an operating temperature of 2400°F. under a controlled atmosphere.

Accurate, dependable instrumentation is required . . . to keep the heating cycle as short as possible, for power economy . . . to avoid temperature override, for protection of furnace and work. Sixteen *ElectroniK* proportional controllers were selected to handle this responsibility, and will help Wyman-Gordon Co. set production records with the largest "Certain Curtain" furnace ever built.

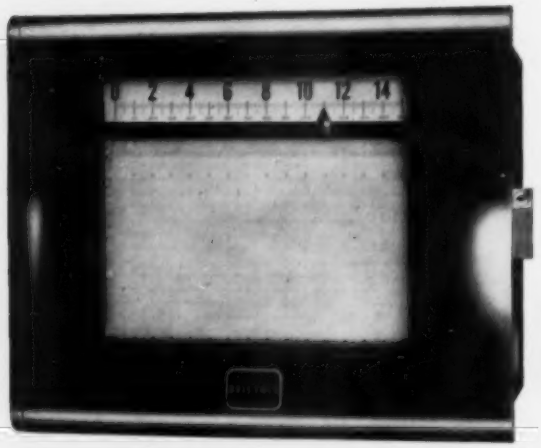
Through continuing cooperation with furnace manufacturers and users, Honeywell is applying the *ElectroniK* principle to countless control problems. The improvements in operating efficiency, product quality, production rate, and savings in materials and labor have earned an enviable reputation for *ElectroniK* controllers.

These instruments, and others in the complete Honeywell line, are highlighted on the opposite page. To help select the type that suits your specific needs, call in your local Honeywell sales engineer for a detailed discussion . . . he's as near as your phone.

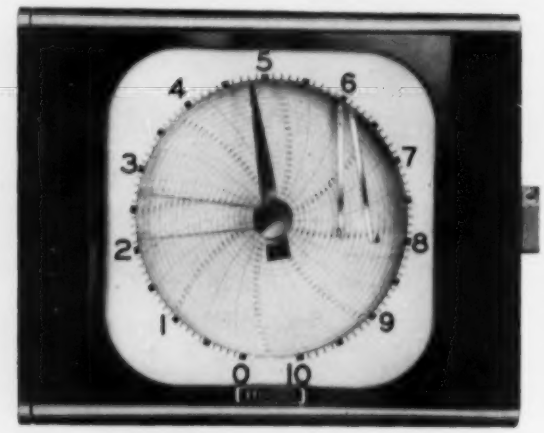
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

WHAT'S NEWS AT BRISTOL . . .



Three reasons temperature control is better with Bristol

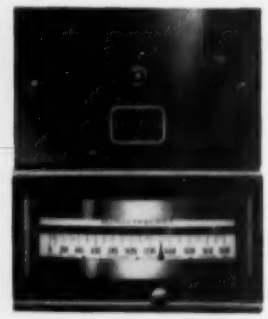


FIRST TWO REASONS are Bristol's Electronic Dynamaster Potentiometers with strip chart or round chart. Here's why:

No-Batt Continuous Standardization in these instruments eliminates need for dry cells. Result: No interruption in operation for standardization, no batteries to replace.

Recorders for every requirement – single-pen, two-pen, and multiple-record (up to 24 points)

Electric and pneumatic controllers for every furnace and oven control mode, including *electric controllers* for on-off, proportional-input, 3-position, proportional, proportional plus automatic reset, and time-program control; and *pneumatic controllers* for on-off, proportional, proportional plus reset, and proportional plus reset plus derivative control.



THIRD REASON: Bristol's Free-Vane® Electronic Pyrometer Controller. No relay chatter with this controller! Bristol's thyratron-operated relay puts a stop to that. Minute changes in temperature – less than 0.003" on scale – close or open the relay with positive trigger action. Available in thermocouple and radiation pyrometer controllers in ranges up to 4000F. New high-torque, rugged millivoltmeter gives greater accuracy and a sensitivity of 15 ohms per millivolt. Separate plug-in control units, variety of control modes available.

Get the whole story on these three rugged Bristol Furnace and Oven Controls. Write for free 48-page Bulletin P1260 today. It contains specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

5.40

BRISTOL *POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION*

BRISTOL'S

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

"Quality in our heat treating calls for GULF SUPER-QUENCH in our tanks"

says Mr. Lloyd Mattson, owner, Quality Steel Treating Co. of Anderson, Indiana.

"QUALITY is not just a name with us. We carry it through every operation in the heat treatment of tools, dies, and precision parts for aircraft and automotive equipment," says Mr. Mattson. "And much of the credit for our quality heat treating belongs to Gulf Super-Quench which delivers deep, uniform hardness without cracking or distortion."

The superior quenching power of Gulf Super-Quench assures deeper, more uniform hardening even on steels of variable hardenability and on parts with variable sections or odd shapes. This results in fewer rejects and a substantial saving in money.

Another important reason for Gulf Super-Quench's high rank among heat treating concerns is its ability to retain its fast dual quenching power indefinitely with only normal make-up. There is no need for additive replenishment.

Perhaps a Gulf Sales Engineer can help you find opportunities to use Gulf Super-Quench profitably in your shop. Consult the telephone directory for the number of your local Gulf office.

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

GULF OIL CORPORATION
1822 Gulf Building

GULF

GULF REFINING COMPANY
Pittsburgh 30, Pa.

Only P&H AC/DC Welders give you

7 Welders in 1

. . . you get AC or DC at the flip of a switch—
plus quick, exact heat from Dial-lectric Control

One P&H AC/DC Welder now does the work of seven separate welding machines. This versatile 1 for 7 P&H machine reduces your capital investment—saves time and money — gives you better welds. The P&H AC/DC Welder also has Dial-lectric control for instant heat adjustment through the entire range.

Because of its flexibility, the P&H AC/DC Welder opens many new welding opportunities for large and small plants. It's so easy to use that even new men make good welds on "difficult" metals. There's a right size P&H AC/DC Welder for most needs. Capacities range from 7 amps to 675 amps. Write today for more information.

HARNISCHFEGER
MILWAUKEE 46, WISCONSIN

I'M SMOOTH-ARC SCOTTY...
and I'm tellin' you seven ways you can use the P&H AC/DC Welder. Take any one of the seven, and it beats anything you've ever used. Send in the coupon for complete information... free!

SEND COUPON TODAY FOR **FREE** INFORMATION

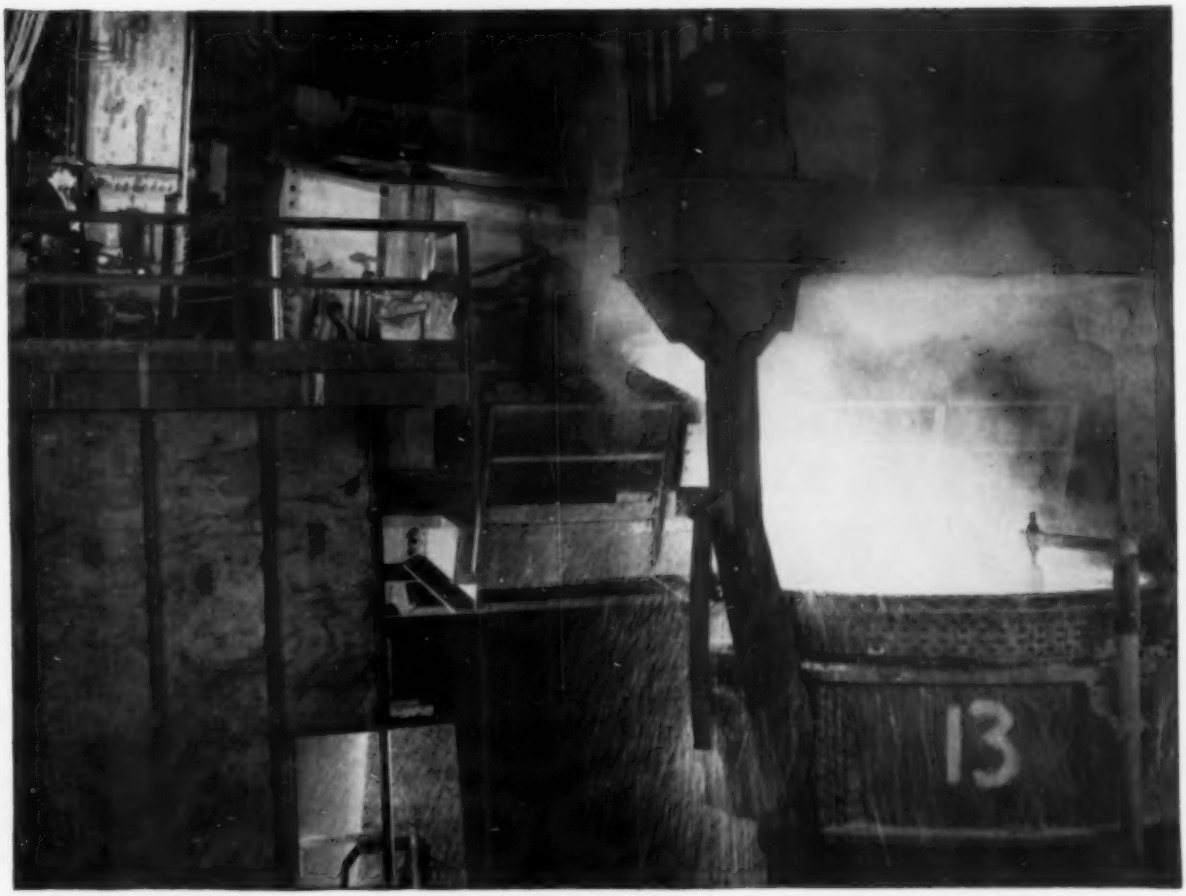
P&H **HARNISCHFEGER CORPORATION**
Welding Division
4549 W. National Avenue, Milwaukee 46, Wis.

Attention: W. R. Stephens, Sales Manager
I'd like to see more information on P&H AC/DC Welders. Please send it to me.

Name ..... Title .....
Company .....
Address .....
City ..... Zone ..... State .....
3088

the P&H *Line*

P&H welding equipment is manufactured and sold in Canada by REGENT EQUIPMENT MANUFACTURING COMPANY LTD., 455 King Street West • Toronto, Ontario, Canada



Because we make 70 chemical determinations per heat—TIMKEN® stainless steel forges more uniformly for you

FROM heat to heat, from bar to bar and from order to order Timken® stainless steel has the uniform chemical composition you need for uniform forgeability. One big reason: we make an average of 70 chemical determinations of every heat.

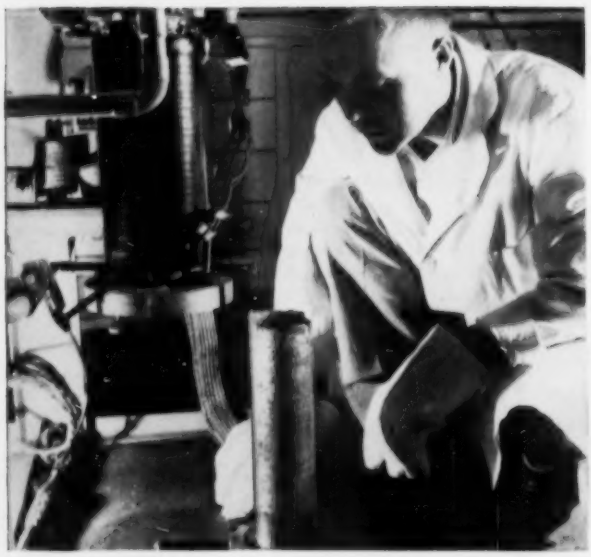
Another reason Timken stainless steel forges more uniformly for you: every man in our mill who works on your order knows how your steel is to be used. We tailor conditioning procedure to your end use. From order to order, the properties you get will be the same. This means that you need make no adjustments in your forging procedures. You save time in your plant. You save money.

Timken forging steels actually save you steel because their good dimensional tolerances produce uniform weight multiples with a minimum of steel lost in flashings. Get all these advantages in your forgings. Specify Timken forging steels. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

TIMKEN
Fine Alloy
STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



Research in titanium reduction and annealing by Dr. E. W. Johnson, Advisory Metallurgist, developed this vacuum arc furnace for commercial use. The consumable sponge titanium electrode, shown, is reduced to a highly pure titanium ingot.

Expanded design engineering is supervised by R. W. Brown, Engineering Manager, for Westinghouse gas and electric furnaces and atmosphere generators. Additional engineering facilities handle induction heating equipment.

Launching a new Industrial Heating Division

L. R. HAGUE OF WESTINGHOUSE CARRIES NEW PROFIT OPPORTUNITIES TO CUSTOMERS

Big and growing opportunities in metal treating are creating a need for broader equipment know-how and service. The answer to these needs is being put before customers by L. R. Hague, Division Manager, in over 10,000 miles of introducing Westinghouse major new Industrial Heating Division.

Cadre of key men

"Westinghouse new organization grows around key men with careers in metallurgical processing," reports Hague. "Their experience expedites problem solving on all types of equipment . . . gas and electric furnaces, atmosphere generators and induction heating equipment applications. Some of these involve more than one type of heat-treating and many installations incorporate work-handling advantages for in-line production."

Turn-key contracts

Manufacturing and field service organizations have expanded, too. They integrate their planning with customer timetables for equipment installation. Full erection and supervision of start-ups are provided in what Westinghouse calls *turn-key* contracts.

Research rapid

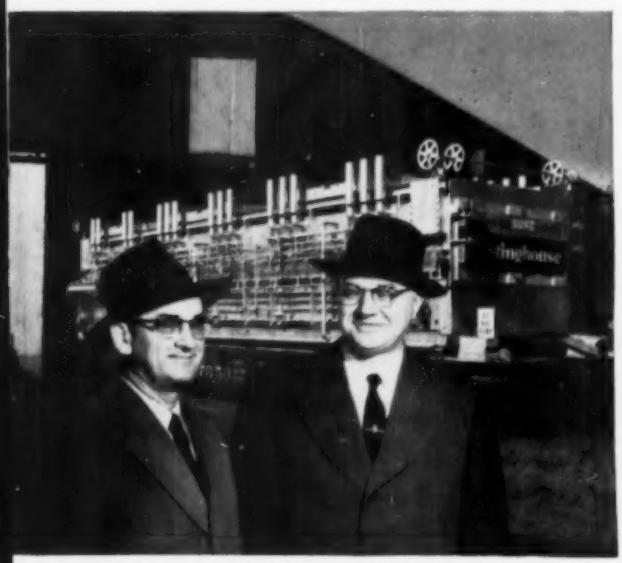
Hague points, in addition, to Westinghouse pioneering in new fields of metallurgy. "Developments in vacuum metallurgy, induction heating and other techniques are progressing rapidly," he said. "Equipment development is a part of Westinghouse large metallurgical research program."

On-the-spot planning

This year many plants plan heat-treating expansion. Many more will check heat-treating obsolescence—looking for troublemakers that cause extra handling, distortion, decarburization or scaling. "Call your local Westinghouse industrial heating sales engineer for counsel on these problems," Hague recommends. "He will bring broad equipment knowledge and service facilities for new profit opportunities." J-10449

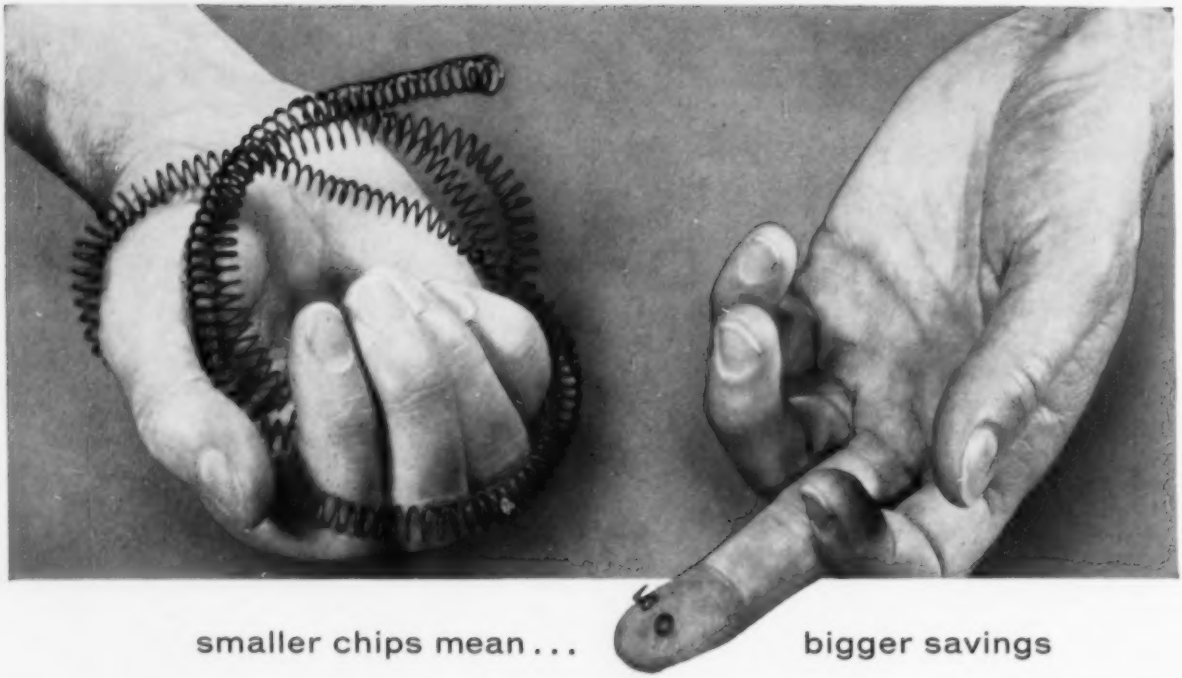
YOU CAN BE SURE...IF IT'S

Westinghouse



Project engineers, C. E. Peck and E. J. Seabold, work with Westinghouse customers in engineering, manufacture and installation of units such as this continuous annealing furnace, to be tested and ready to go in the customer's plant.

Industrial heating sales engineers are kept abreast of new developments and techniques in regular reviews with L. H. Gillette, Marketing Manager, and R. R. La Pelle, Furnace and Atmosphere Generator Application Manager.



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These short, fast-breaking chips have real meaning to cost-conscious purchasing and production men. In an ever-increasing number of shops, small chips like these mean that the switch has been made to Rycut steels. They mean that tools are turning faster—that production is up as much as 200%.

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- Up to 200% more parts can be produced per machine hour!
- Tool life is lengthened as much as 300%!
- Finish is improved!

There's a Rycut leaded alloy for every application. Use RYCUT 20 when you need a carburizing alloy; RYCUT 40 for .40 carbon alloy applications; and RYCUT 50 for .50 carbon alloy uses. Every one is a cost-cutter.

Figure how much this increased production and longer tool life would lower costs in YOUR shop—and raise your profits! Call your nearby Ryerson plant today . . . large stocks assure you of quick shipment.

NOW LEADED PLATES—Ryerson's New E-Z-Cut is the first leaded plate steel available from stock. It cuts faster, polishes easier than other free-machining plate steel.

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Metal Progress
Volume 69, No. 4 April, 1956

Fifty Years of Progress in Electric Furnace Steelmaking

By HOWARD J. STAGG*

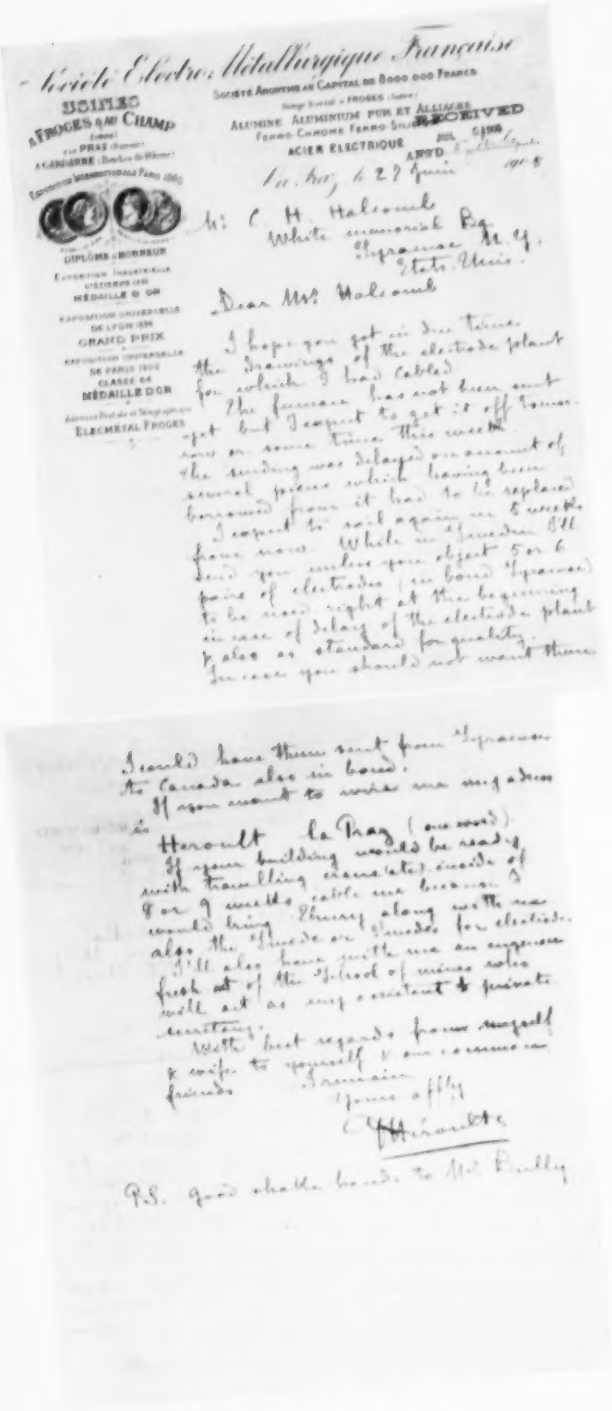
Fifty years ago the first electric arc steelmaking furnace in America started production of toolsteels in competition with crucible furnaces. It has since made the crucible method obsolete and now, in many instances, produces steel at lower cost than openhearth furnaces. (D 5, TS, AY)

On April 5, 1906 the first heat of electric arc furnace steel made in America was tapped at the Halcomb Steel Co., now the Sanderson-Halcomb Works of Crucible Steel Co. of America. The first furnace had a rated capacity of 3 tons; in 1956, 200-ton heats are being melted and total electric arc furnace production will exceed 11,000,000 tons. Early production was limited to carbon toolsteel; now, the kinds of alloys melted range from mild steel to the complex superalloys used in jet engines.

At that time the best way to make toolsteel was by the crucible process and the product was governed entirely by the skill and experience of the melter. The melter's secrets were closely guarded and handed down from father to son; as a matter of fact the crucible steel melter at Halcomb was a son and grandson of melters at the Sanderson Bros. Steel Co. of Sheffield, England. C. Herbert Halcomb who founded the Halcomb Steel Co. in 1905 was himself the son of the managing director of the Sheffield firm.

The equipment used for crucible steel was essentially a high-temperature furnace which contained up to 30 crucibles made from graphite and clay. Each crucible held up to 60 to 100

*Sanderson-Halcomb Works, Crucible Steel Co. of America, Syracuse, N.Y.



Société Electro-Métallurgique Française

USINES
A FROGES & AU CHAMP

Aluminium Aluminium pur et Alliages
Ferro-Chrome Ferro-Silicium
Acier électrique

RECEIVED
1905

La Praz, le 27 Juin 1905

M. C. H. Halcomb
White memorial Bg
Spuyten Duyvil N.Y.
États-Unis.

Dear Mr. Halcomb

I hope you got in due time the drawings of the electrode plant for which I had cabled. The furnace has not been sent yet but I expect to get it off tomorrow or some time this week. The shipping was delayed on account of several pieces which having been borrowed from it had to be replaced. I expect to sail again on 5 weeks from now. Which is Tuesday 8th Aug. you unless you object for 6 pairs of electrodes (in bond Spurenden) to be sent right at the beginning in case of delay of the electrode plant & also as standard for quality. In case you should not want them

should have them sent from Spuyten to Canada also in bond.
If you want to write me my address is
Heroult La Praz (one word)
If your building works be ready with travelling crane late inside of 8 or 9 weeks cable me because I would bring Thury along with me also the electrodes for electrodes. I'll also have with me an engineer fresh out of the school of mines who will act as my assistant & private secretary.
With best regards from myself & wife to yourself & our common friends
Yours affly
P. Héroult

P.S. good thanks be to Mr Bully

Letter From Heroult to Halcomb Explaining Delivery Delay

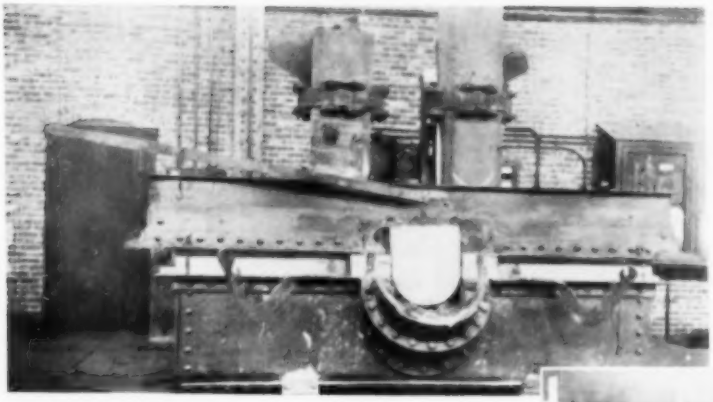
Paul Louis Toussaint Heroult (1863-1914)

lb. and was charged with refined iron and some times ferromanganese and ferrosilicon. Speed of melting, holding time and temperature, and "tapping" temperature were controlled entirely by the skilled eye of the melter. When he said that the steel was ready the crucible was lifted from the furnace and its contents poured either directly into an ingot mold or into a ladle with others so that larger ingots could be made.

Halcomb Steel was founded as a crucible steel company and the expansion in capacity planned for 1906 was to have been a 24-pot crucible furnace plus one small stationary openhearth to make drill steel. R. H. Bully was hired from Canton Steel Co., to be superintendent and chief engineer. He managed to persuade the original board of directors that the electric arc furnace developed by Paul L. T. Heroult in France would be the most economical and efficient equipment for toolsteel production. The plan proposed by Heroult was to refine steel in the openhearth where the sulphur would be reduced, then transfer the hot metal to the electric arc furnace for further refining and additions of carbon and alloying elements.

The First Electric Furnace

The furnace was ordered in 1905 but because of numerous delays, the installation was not completed until 1906. Instead of the stationary openhearth furnace originally planned, a 20-ton Wellman Seaver Morgan tilting openhearth was



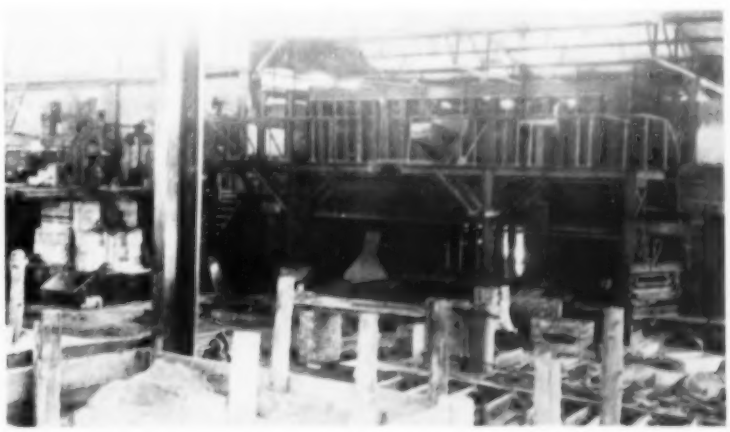
Front and Side Views of First American Electric Arc Furnace

installed alongside and on the same level. The electric arc furnace at first had a rated capacity of 3 tons. It was basic-lined and powered by a single-phase 500-kw. generator with high amperage and low voltage. The first electrodes were made in Sweden and were quarter octagon in cross section, about 15¾ × 15¾ × 80 in. There was no method of joining electrodes and about 60% of each electrode was discarded as a stub. Heroult brought two men from Sweden and together they tried unsuccessfully to make electrodes at Syracuse. After that they imported electrodes from Sweden for several years.

At first the roof was only 16 in. high at the arch and 7 in. at the skewback. It was made of silica brick which melted, dripped into the slag, upset the slag balance and cut the basic bottom and sides. The dimensions were increased until finally the roof was 24 in. at the arch and 14 in. at the skewback. In 1907, 4-ton heats were being made.

Early heats were all straight carbon toolsteels. The first four were made with cold charges but after that all heats were duplexed. It was difficult to say how the quality of the steel compared with that made in crucibles since the only control measurement was chemical analysis. Toolsteel users wanted an alloy that had "body", a property of the steel that would give both toughness and wear resistance to the tool after any one of the many kinds of heat treatment used by the blacksmiths and toolmakers of that day. The best producers were those who consistently made a steel that would be fine grained over a wide hardening temperature range.

We still have a piece of a 1⅞-in. square bar



Installation of 20-Ton Openhearth Furnace Beside the 3-Ton Electric

Bar From Heat Melted in April 1906 and Fracture Surface of Hardened Sample

from Heat 4 D 6, the fourth heat made in the Heroult furnace in April 1906. About two months ago we cut a test disk and hardened it by water quenching from 1450° F. It was fine grained and a pretty good steel, even measured by modern standards. Unfortunately, the effects of all the variables in melting practice for the electric arc furnace were not known and good toolsteel could not be provided as consistently as in the crucible furnaces. Even as late as 1916, John A. Mathews, Crucible's director of research, stated that electric furnaces could not produce toolsteel of the quality obtainable in crucible furnaces.

Records of the melting practice used at the beginning can't be found but we do have logs made in 1907. At that time the furnace had been increased in size to hold 4 tons. The charge was 7550 lb. of hot metal from the openhearth, 30 lb. of crushed coal and 40 lb. of "Carburite", probably a coke mixture. The heat took 2½ hr. and 525 kw-hr. to produce 7515 lb. of steel – 147 kw-hr. per ton. Fourteen 8-in. ingots were produced and the analysis was quite close to that specified. They wanted 0.90% C, 0.13% Si and 0.21% Mn and obtained 0.86% C, 0.19% Si and 0.24% Mn. The phosphorus was 0.013% and the sulphur was 0.025%.

Compositions of the First Heats Made in the Heroult Furnace

Heat No.	C	Mn	P	S	Si
1 D 6	0.976	0.31	0.032	0.025	0.28
2 D 6	1.044	0.33	0.021	0.022	0.29
3 D 6	0.742	0.30	0.020	0.030	0.19
4 D 6	0.873	0.28	0.018	0.025	0.25
5 D 6	0.721	0.40	0.026	0.027	0.23
6 D 6	1.049	0.46	0.039	0.021	0.36
7 D 6	1.040	0.26	0.031	0.022	0.28
8 D 6	1.060	0.32	0.015	0.019	0.30
9 D 6	0.984	0.19	0.012	0.025	0.17
11 D 6	1.058	0.24	0.013	0.022	0.39
12 D 6	0.979	0.21	0.010	0.023	0.16
13 D 6	1.339	0.24	0.016	0.027	0.16
14 D 6	1.056	0.24	0.019	0.017	0.21
15 D 6	0.895	0.19	0.014	0.016	0.17
16 D 6	0.823	0.26	0.020	0.012	0.32
17 D 6	0.886	0.20	0.028	0.019	0.18
18 D 6	1.063	0.15	0.013	0.034	0.11
19 D 6	0.976	0.26	0.026	0.014	0.24

Demand for Alloy Steels

In 1908 and 1909, the automotive industry began to become important to the steel industry and demanded better alloy structural steels than could be made in openhearth furnaces. In early 1909, the records of old No. 1 showed heats of 3½% nickel, chromium-vanadium and nickel-chromium steels. Toolsteel heats became relatively scarce as more and more production was required for the "horseless carriage" market.

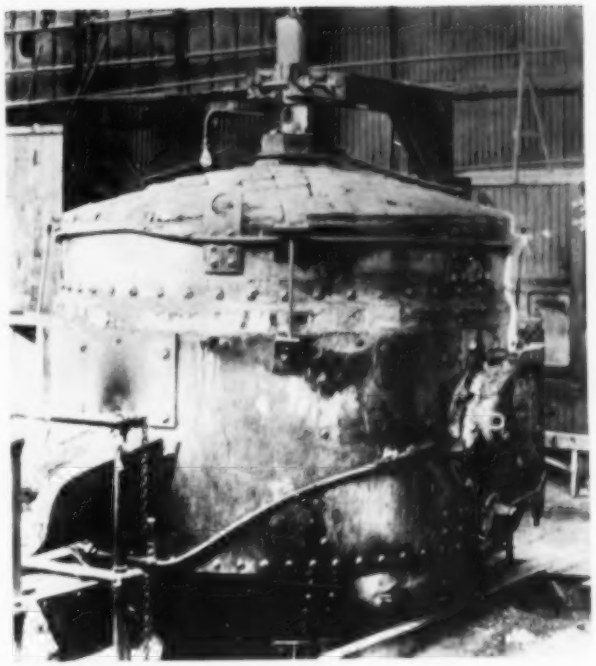
The early melting practice used for alloy steels was good and always produced steels that were fine grained over a wide range of forging and hardening temperatures. Such a steel was a boon to the automotive industry. It took a lot of punishment from the drop forger and heat treater and even with their crude furnaces and lack of temperature control, the product was good.

By 1915, American production of electric furnace steel had increased to about 100,000 tons per year; most of it was alloy steel. In the same year, crucible steel production was over 255,000 tons. The demand for quality steel during World War I caused a tremendous expansion and by 1920, electric furnace capacity had increased to 800,000 tons while crucible production dropped slightly to about 225,000 tons.

Not all the furnaces were Heroult type. At Halcomb, which had become a division of Crucible Steel Co. of America in 1911, six electric furnaces had been added. Three were 6-ton Heroults, two were 5-ton Greaves-Etchell furnaces and one was a 4-ton Snyder furnace. The latter furnaces had electrodes in the bottom. Although they produced good steel there were so many production and maintenance difficulties that their use was abandoned and all modern furnaces use the original Heroult three-electrode submerged-arc principle.

Between 1920 and 1930, electric furnace melters finally acquired the know-how necessary to produce high-quality toolsteel consistently. From that time on, crucible furnaces were doomed. By 1930, crucible production dropped to 33,000 tons; in 1940, 5000 tons was produced; in 1950, 20 tons of crucible steel was melted. In the 1920's, the demand for stainless steels which could be produced economically only in electric arc furnaces caused an acceleration in the growth of the industry and by 1930, production had reached 1,500,000 tons.

Experience and better understanding of furnace operating variables had much to do with the successful growth of electric furnace production but there were many other contributing factors. Among these are the gradual improvements of refractories, better quality electrodes, improved mechanical and electrical controls, increase in furnace size, top charging and assurance of adequate electric power at low cost. The Heroult furnace was conceived as a unit to compete with the high-cost crucibles for toolsteel production. It lost its first battle but finally won the war. Now electric furnaces are competing with openhearths, and at least in nonintegrated plants, can produce steel at lower cost.



Snyder Electric Furnace (1915)

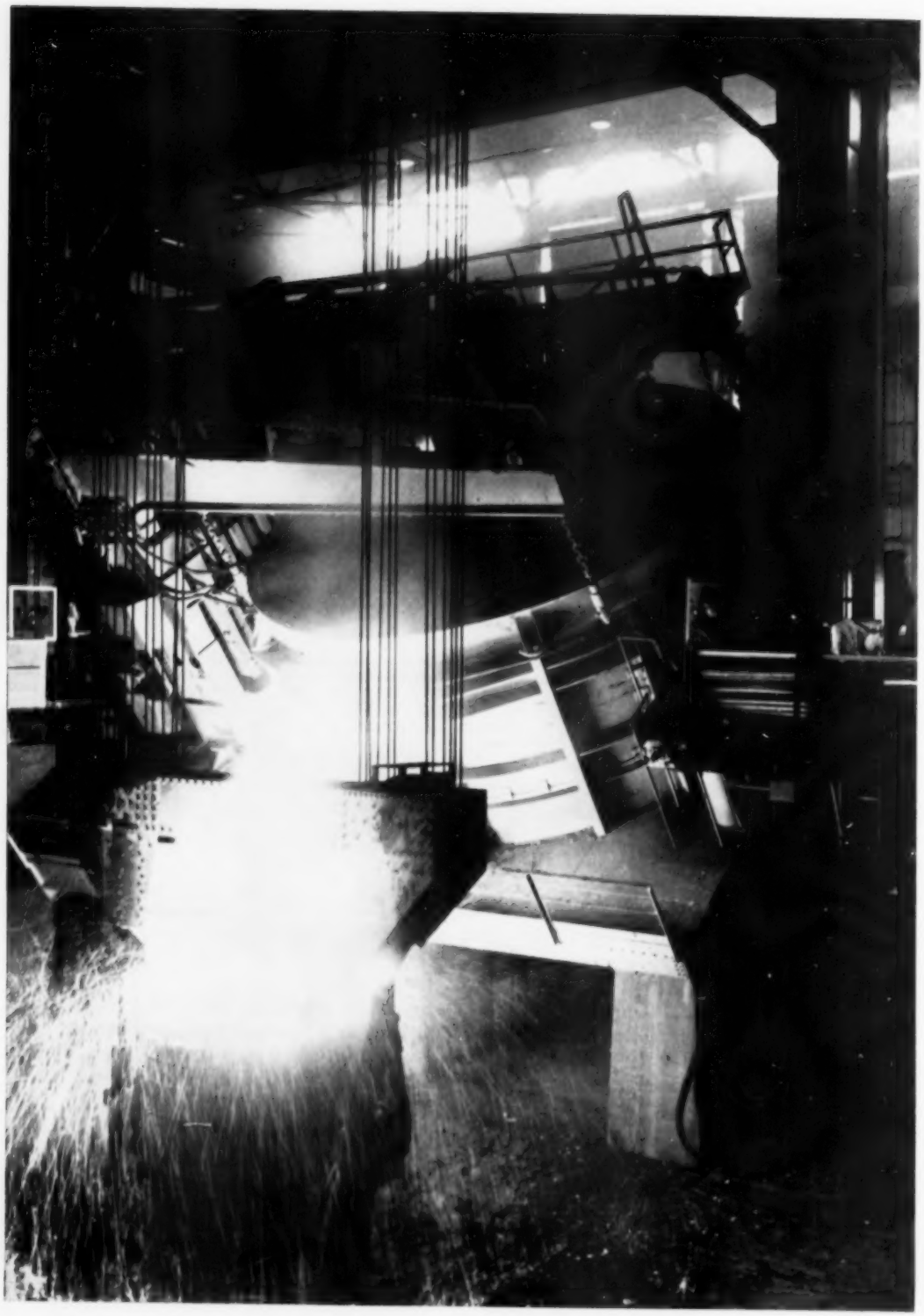
Annual Steel Production*

	Openhearth	Electric	Bessemer	Crucible
1915	29,900	100	14,000	255
1920	45,200	800	13,300	224
1925	51,600	900	12,800	177
1930	61,800	1,500	9,600	33.5
1935	68,500	1,100	8,800	11.9
1940	73,700	1,900	6,000	5.4
1945	84,200	5,500	5,900	3.8
1950	87,000	6,800	5,500	0.02
1955	110,200	10,800	4,800	0.04

*Figures are in thousands of tons. Source: American Iron and Steel Institute.

Future Trends

The problems confronting the fully integrated plants are, however, quite different. At present, there seems to be no definite trend to substitute the electric furnace for the openhearth. Without going into a lengthy discussion of the many pros and cons Harry W. McQuaid states: "In my opinion there is no sound basis at present for expecting that a fully integrated steel plant operation capable of producing 1,000,000 tons of carbon steel ingots a year will replace its present openhearth equipment with electric furnace equipment, unless developments in the reduction of the carbon and silicon in hot metal by cheap oxygen, or otherwise, encourage the use of the electric furnace. A step in this direction is being taken by the McLouth Steel Co. of Detroit. Even in this case, it must be remembered that new electric furnace equipment is being installed; it is not being compared with openhearth equipment that has already been written off. The McLouth plant will bear watching with the greatest interest to determine whether or not the bessemer converter with the aid of oxygen (LD-proc-



200-Ton Arc Furnace at McLouth Steel Corp. Built by American Bridge Co.

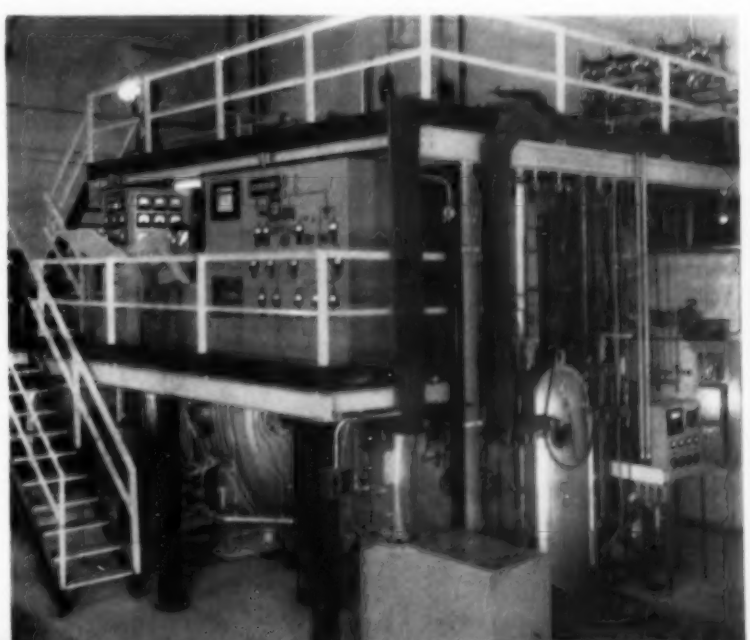
Greaves-Etchell Electric Furnaces (1918)

ess) can in combination with the modern electric furnace, produce from a carefully worked out, most economical combination of hot metal and scrap, ingots that are economically competitive with those from the modern openhearth."

In the immediate future, electric furnace production will increase steadily and take a bigger share of the carbon and low-alloy steel market. Furnaces will increase in size; the largest now can produce 200 tons. This furnace, built by American Bridge Co., is in operation at McLouth Steel Corp. in Detroit. The inside diameter is 24 ft., 6 in. but there is no mechanical reason why a 30-ft. diameter top-charge furnace could not be built. The development of refractory guns for fretting the sidewalls and banks has removed the old size limitation that depended on how far a man could throw patch material.

Fifty years from now, the steel industry will have expanded and changed but it isn't safe to predict what the changes will be. Perhaps openhearths will be obsolete and as difficult to find as crucible furnaces are now. It may be significant that only a few months ago the largest vacuum induction melting furnace in the world started production at a site less than a quarter-mile from the park where the original Heroult furnace is on display. The vacuum furnace has a capacity of 2200 lb. and is producing for Vacuum Metals Corp., which is jointly owned by Crucible Steel Co. of America and National Research Corp. Alloys can be melted and poured into ingot molds and cooled entirely under vacuum and the entire operation is controlled by the melter at the instrument console.

Perhaps in 2006 all alloys will be melted or poured under vaccum and instead of being cast into separate ingots, will be cast continuously. If automation grows in as spectacular a fashion as electric furnace production has, then we could have a completely automatic steel mill run entirely by some kind of computing machine. Can you imagine the frustration among metals engineers in metalworking plants when they call up to complain to a computing machine that its steel is no good?



Largest Vacuum Induction Melting Furnace in the World at Vacuum Metals Corp.

High-Temperature Parts Based on Titanium Carbide

By WALTHER L. HAVEKOTTE*

Properties vary with composition of metallic binder, carbon content and porosity. Manufacturing methods are stabilized for products of light weight and high rupture strength. Unfortunately, all are quite brittle at room temperature. (H general, Ti, C-n)

CONSIDERABLE effort has been spent during the past five or six years to develop an improved cermet for high-temperature applications. The initial work on some of the cermets was done by Hard Metal Tools in Coventry, England, and by Mettallwerk Plansee in Reutte, Austria.

One which has received particular attention is based on titanium carbide, and it is highly probable that it can be successfully applied. This pointed up the requirement that some manufacturing facilities be established to fabricate representative parts. Firth Sterling Inc. therefore received a contract to build a pilot plant and work out some "bugs" which might appear. This paper describes some of our findings – not only in our own laboratory work but in production of certain parts.

Production of the Carbide – Titanium dioxide was heated with carbon to the following reaction:

$$TiO_2 + 3C \rightarrow TiC + 2CO$$

Powdered oxide and graphite were intimately mixed, pressed into slugs, and then heated in either vacuum or hydrogen. A typical cycle for an 11-lb. mixture, heated in "vacuum", is as follows: Temperature reached 2000° F. in 2.7 hr., during which time the vacuum was always less than 30 microns. During the next hour the temperature increased to 2200° F. and the pressure to 800 microns, at which it was held for 2.5 hr. while the temperature attained 2700° F. Thereupon the pressure fell steadily as the temperature increased; at the end of the heat temperature was almost 3000° F. and pressure had fallen to about 20 microns.

This run produced TiC having a total carbon content of 19.38% and only a trace of free graphite. However, the usual analysis of the carbide reduced in vacuum was about 19.5% total carbon and 0.8% graphite. We believe that a higher *combined* carbon would result if the mixture could be heated to 4000° F.

There is a systematic variation in particle size of the carbide produced in a hydrogen atmosphere and its carbon content with the amount of carbon in the original mixture, as shown below. We believe that 19.0% combined carbon

Carbon in Mix	Combined Carbon	Graphitic Carbon	Particle Size
30.5%	19.2%	0.2%	3.4 microns
31.0	19.25	0.8	2.4
31.5	18.9	2.2	2.2

is the minimum for cermets. (Oxygen and nitrogen in the TiC run between 0.2 and 0.3%.)

Preparation of Grades – Various "grades" of TiC cermets were produced by varying the amount of carbide and the amount and quantity of metallic binder – nickel and chromium powders, usually with a little molybdenum and sometimes with cobalt as well. In brief, specimens were prepared as follows:

The minus-100 mesh TiC and metal powders were ball milled together for 120 hr. in steel mills using tungsten carbide balls and acetone. The product was then dried, mixed with 3% paraffin dissolved in carbon tetrachloride, and cold pressed at 20,000 psi. The paraffin must be thoroughly mixed, else half-moon shaped macroporosity would occur. These billets were half

*Manager of Cermet Research, Firth Sterling Inc., Pittsburgh. This paper is adapted from one read last June before the Second International Seminar on Powder Metallurgy in Reutte, Austria.

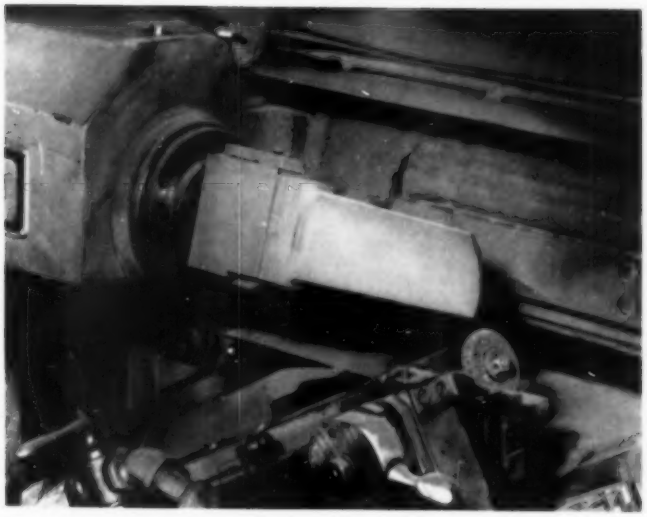


Fig. 1 – Jet Engine Bucket Being Shaped From Half-Sintered Block of Grade FS-12 on Ex-Cell-O Precision Profile Grinder by Bay State Silicon Carbide Wheel No. C-46-G

sintered at 1400 to 1600° F., depending on the hardness desired.

It is extremely important that half-sintered billets be cooled to room temperature under a controlled atmosphere, otherwise the pieces will oxidize. (This matter will be considered in some detail a little later.) They were then shaped (Fig. 1) to the desired dimensions with silicon carbide or diamond wheels, keeping in mind that the piece will shrink about 20% during final sintering. Shaping requires extreme care because the billets are very fragile and only chalk hard.

Shaped parts were final-sintered in the presence of liquid phase under vacuum at 2250 to 2500° F. Temperature depends on the composition of the particular grade and must be maintained within narrow limits to obtain optimum properties. Pieces were ground to final size with 100 to 150-grit diamond abrasive wheels, plus a large amount of cooling liquid and very light cuts. A Carborundum wheel designated as No. D 100, N 100, BR, 7 × ½ × 1¼, performed very well with a depth of cut of 0.0005 in.

While the above indicates the principal steps of the manufacturing operation, a number of additions and precautions are necessary:

When large pieces are to be prepared it is essential that the ball-milled powders be annealed prior to pressing; otherwise the billets would crack during half-sintering. (Annealing recrystallizes the cold worked binder powders.)

Titanium carbide cermet powders oxidize rapidly in the air. Nickel of the binder probably oxidizes first, TiC next, and chromium last. Since oxidized samples warp during final sintering, it is essential that the ball-milled powders or the half-sintered billets be protected. Powders should be stored in tightly sealed containers, and half-sintered billets held under vacuum except for necessary operations such as grinding to shape. Paraffined powders can probably be stored in open air for as much as two months without undue concern.

The maximum time between half-sinter and final-sinter for samples in open air should be less than two days. Should this two-day limit be exceeded, and if a small amount of warping cannot be tolerated, the shaped samples should be passed through a furnace operating in *dry* hydrogen at 1500° F. The dew point of the hydrogen must be at least −50° F. to permit the following reduction:

$$NiO + H_2 \rightarrow Ni + H_2O$$

The above treatment will be of no use if the TiC particles have been oxidized.

The pressure in the furnace during final-sintering is not of extreme importance; it varied from 10 to 30 microns. However, the leak rate or the seepage of air into the furnace is of extreme importance. Specimens sintered in furnaces with a high leak rate oxidized and warped; specimens sintered in a furnace with low leak rate did not warp. The leak rate in our

Table I – Analysis and Amount of Binder in Various Grades

Grade	Components of Mix					Binder in Cermet
	Ti + C	Ni	Cr	Mo	Co	
FS-2	61.6%	29.6%	7.4%	1.4%	—	34.2%
FS-3	48.6	40.0	10.0	1.4	—	47.2
FS-8	61.6	22.2	7.4	1.4	7.4%	34.2
FS-9	48.6	30.0	10.0	1.4	10.0	47.2
FS-10	33.6	52.0	13.0	1.4	—	62.0
FS-12	33.6	39.0	13.0	1.4	13.0	62.0
FS-26	55.1	40.0	4.9	—	—	42.2
FS-27	44.5	50.0	5.5	—	—	53.0
FS-65	50.3	35.0	10.0	4.7	—	43.7
FS-77	65.3	23.0	7.0	4.7	—	28.9

operating furnace (39 cu. ft. capacity) was very low; the pressure would creep up only 0.5 to 1 micron per hr.

Chemical Analyses – Table I gives the chemical compositions of some cermet grades we have produced and studied. All contain nickel and chromium in the binder, and most of them a small amount of molybdenum which increases "wettability" and strength. Final sintered pieces of all grades contained approximately 0.14% nitrogen, 0.50% tungsten, and 1.0% iron. These contaminants did not appear to be harmful.

It will be observed that the sum of the percentages in columns No. 2 to 6 in Table I totals 100. However, the sum of the metallic components is greater than the amount of binder noted in the last column. It was extremely difficult to estimate this figure, for the following two reasons:

1. A small change in the carbon content of some of the cermets altered the distribution of chromium between the binder and the chromium carbides (Cr_7C_3 and Cr_3C_2).

2. But few equilibrium diagrams were known.

Consequently the amount of binder was calculated on the following conditions:

1. Chromium solubility in TiC is found to be in the ratio of 4 parts chromium to 96 parts TiC. (It was assumed that the chromium was present as Cr_3C_2.)

2. Approximately 80% of the remaining chromium is in the binder. The rest formed Cr_3C_2 or Cr_7C_3, and these carbides appear in the microstructure. This division of chromium between the binder and the carbides depends on the amount of carbon.

3. It was assumed that molybdenum is divided equally between the carbide and the binder.

Microstructure

Microstructure of the titanium carbide cermets is a large story by itself, and may be only sketchily presented in this article. Some hints on techniques may be useful.

Samples for metallographic examination should be first mounted in bakelite, surface ground until flat, polished on paper (with olive oil for lubricant) first with No. 4 diamond powder, then No. 6 powder, and finally with Hypreze Diamond Compound No. 1-W-47. Haloid and Rectigraph Photocopy paper was used.

Unetched samples should be examined at 200 and 1500 diameters to determine porosity and graphitic carbon. If inferior mechanical properties are to be avoided, we believe that the amount of porosity shown at 200 diameters should be less than A-2 in A.S.T.M. specification B 276-54.

Poorly polished samples will lead the inexperienced metallographer to believe the specimen has more porosity than it really has. The grains of titanium carbide will contain a number of very small black dots unless the specimen is very carefully polished during the final operation to eliminate them.

Polarized light distinguishes between porosity and graphite in the unetched sample; porosity is bright while graphite will remain black. Another distinguishing feature is distribution; graphite will be in clusters while porosity is evenly scattered.

Major constituents in the microstructure may be differentiated by etchant, as well as indicated. Metallic binder was leached from samples of Grades FS-10 and FS-12 by hydrochloric acid, and X-ray diffraction patterns of the residues

Fig. 2 – Sample of FS-9, Etched Electrolytically With 10% Oxalic Acid, 1500 ×, 47.2% Binder

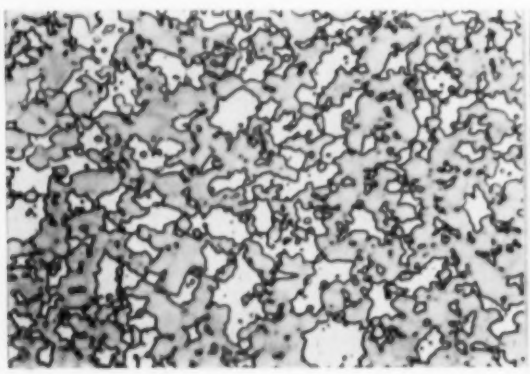
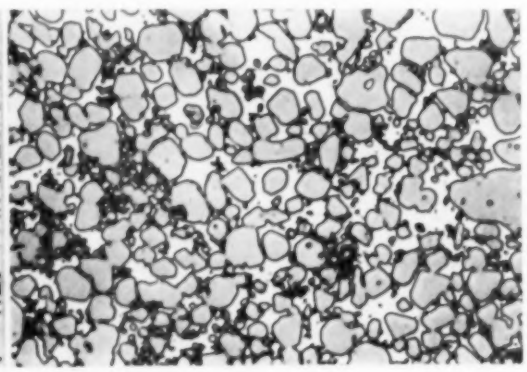


Fig. 3 – Sample of FS-27, Etched Electrolytically With 10% Oxalic Acid, 1500 ×, 53% Binder



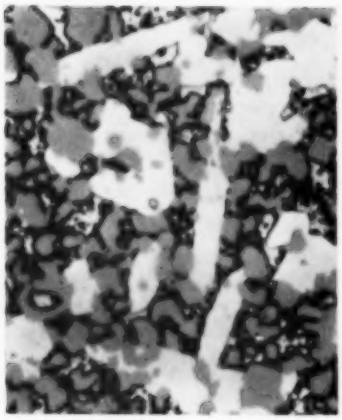


Fig 4 – FS-10 A, Oxalic Etch, 1500 ×

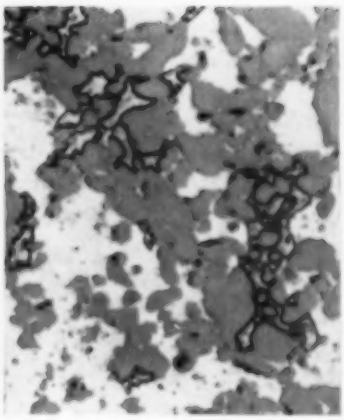


Fig. 5 – FS-10, KOH Etch

Fig. 6 – FS-10 B, Oxalic Etch, 1500 ×

showed unmistakably the two chromium carbides Cr_3C_2 and Cr_7C_3. Microstructure and proportionate amount of the various chromium carbides depended only on the amounts of chromium and carbon in the original mix, and not on how the chromium was added – whether metallic powder, a cobalt-chromium alloy, or any of the carbides Cr_4C, Cr_7C_3 or Cr_3C_2.

Figures 2 and 3 show Grades FS-9 and FS-27, respectively with 47.2 and 53% of binder. (FS-27 is high nickel, low chromium – see Table I.) The white areas are binder, the gray areas are TiC, and the black spots are Cr_3C_2.

Figures 4 and 5 are FS-10 A with 20% Cr and 7.4% C, etched in two ways to show the various carbides. In Fig. 4 (electrolytic oxalic etch) TiC is dark gray, binder is light gray, and Cr_7C_3 is the white constituent.

This latter carbide contained much binder metal and titanium carbide in solution; one observes a shap grain boundary between it and the binder areas, but none between the two carbides. Figure 5 shows FS-10 with 13% Cr and 6.8% C, electrolytically etched in 5% KOH. In it the particles outlined in black are Cr_3C_2, the gray areas are TiC, and the binder is white.

Figure 6 is of FS-10 B (20% chromium) but with higher carbon: 8.4%. After etching in oxalic acid TiC shows dark gray, Cr_3C_2 light gray, and binder white. While it is not known what reactions take place, it is believed that excess carbon robs the binder of chromium.

Figure 7 shows the effect of carbon in a portion of the TiC-Ni-Cr diagram maintaining 35 parts TiC to 52 parts Ni. Phase identification was made by metallographic and X-ray diffraction. This diagram was of tremendous help in correlating chemistry, microstructure and properties.

Mechanical Properties

Table II lists a few properties for the various grades, and other important data are plotted in Fig. 8 and 9. Densities were measured by water displacement. The transverse rupture specimens (3/16 × ⅜ × ¾ in.) were broken by loading at the center of a 9/16-in. span, applied at the rate of 6800 psi. per sec.

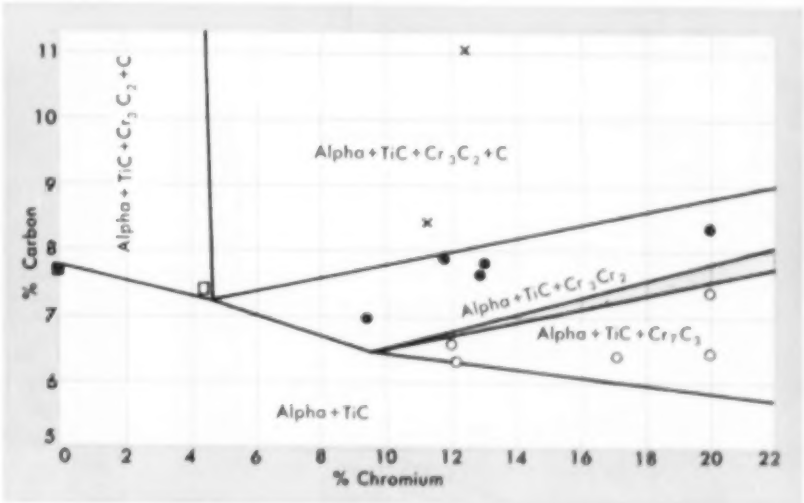


Fig. 7 – Portion of Ternary Diagram (TiC-Ni-Cr) in Which the Proportion of TiC to Ni Is 35 to 52, Showing Phases Existing After Slow Cooling to Room Temperature. Tinted triangle represents alpha + TiC + Cr_3C_2 + Cr_7C_3

Table II – Some Properties of the Cermets

Grade	Density	Oxidation at 1800° F. *(a)*	
		100 Hr.	200 Hr.
FS-2	6.00	9.0	15.6
FS-8	6.12	11.0	23.9
FS-9	6.47	7.5	12.3
FS-10	6.95	6 ±	10 ±
FS-12	6.95	6 ±	10 ±
FS-26	6.25	31.5	47.6
FS-27	6.55	7.6	13.6
FS-65 G	6.25	6.1	9.5
FS-77	5.92	—	—

(a) Mg. gain per sq. cm. of surface.

Oxidation resistance was obtained by measuring the weight gain per unit of surface area on a specimen 3/16 × ⅜ × ¾ in., surface ground all over prior to testing. Air saturated with water at 75° F. was passed through the furnace to maintain a uniform oxidizing atmosphere.

Stress-rupture data were obtained, in general, on specimens with 1-in. gage length, 0.160 in. diameter, and shoulder 0.330 in. diameter – the whole specimen being 1.75 in. long. Impact tests used unnotched Charpy bars 0.394 × 0.394 × 2.165 in. long, which were broken in a 16-ft-lb. Baldwin machine whose hammer has a 2-ft. drop with a striking velocity of 11 ft. per sec.

The following general conclusions may be made from these and other data:

1. Densities, transverse rupture strengths, and impact resistances increased with an increase in binder content, while stress-rupture strengths and hardnesses decreased.

2. Oxidation resistance increased (gain-in-weight decreased) as the amount of chromium was increased.

3. Carbon content had a tremendous effect on stress-rupture strength. For example, the 100-hr. strength for FS-65 at 1800° F. decreased from 13,500 to 7,000 psi. as the final carbon content increased from 9.5 to 11.4%.

4. The amount of chromium carbide in the microstructure affected the toughness. For example, the impact resistance decreased from 5.7 to 3.2 ft-lb. as the amount of chromium carbide increased from 0.5 to 13%.

Some comparisons may be made with X-40, one of the best high-temperature alloys. It is a cobalt-base alloy hardened with tungsten and carbon. The density of X-40 (8.61) is approximately 30% higher than FS-9, while FS-9 has a 30% greater stress-rupture strength for 100 hr. at 1800° F. than the 9400 psi. for X-40. When com-

Fig. 8 – Effect of Binder Content on Density, Hardness and Transverse Rupture Strength of TiC Cermets

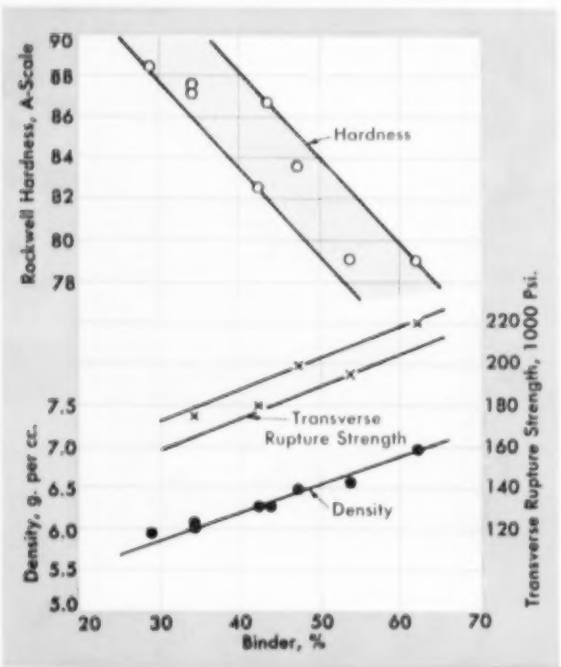
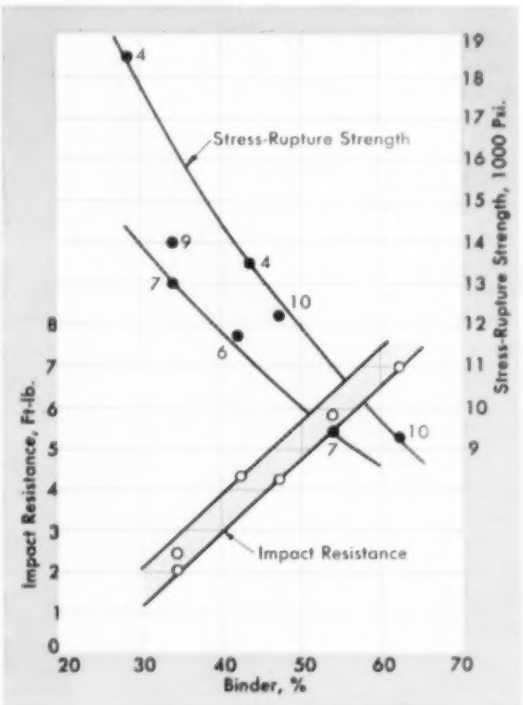


Fig. 9 – Effect of Binder Content on Impact Resistance and Stress-Rupture Strength for 100 Hr. at 1800° F. Figures alongside points indicate % elongation in 1 in. at rupture



paring FS-9 and X-40 on an equal density basis, as the two materials must be compared when considering rotating parts, FS-9 has a 72% greater 100-hr. stress-rupture strength at 1800° F. than X-40.

The chief obstacle to the use of cermets today is their fragility. While great strides have been made in improving their toughness during the past five years, it still must be much higher before they can be used as vanes and buckets in jet planes. When the impact resistance approaches approximately one-third the 44 ft-lb. of X-40 (at 70° F.) then cermets will have passed the great milestone. A number of very promising research approaches to this problem are being investigated.

G. M. Ault and G. C. Deutsch presented a number of other properties, and they compared cermets with other materials in "Applicability of Powder Metallurgy to Problems of High Temperature Materials", *Journal of Metals*, November 1954, p. 1214. They also give a long and detailed list of references which should be of tremendous help to anyone becoming acquainted with the subject. The article by Roger A. Long on "Super-Refractory Materials" in *Metal Progress* for September 1955, p. 123, should also be consulted.

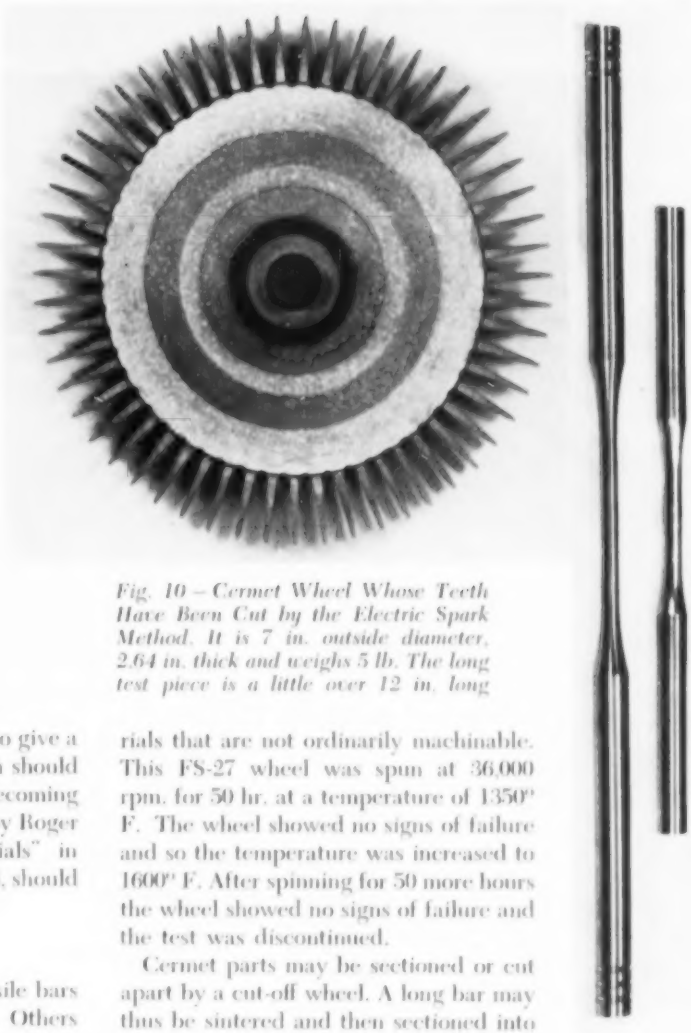


Fig. 10 – Cermet Wheel Whose Teeth Have Been Cut by the Electric Spark Method. It is 7 in. outside diameter, 2.64 in. thick and weighs 5 lb. The long test piece is a little over 12 in. long

Parts

Figure 10 shows a wheel and two tensile bars made from the grades discussed above. Others include impact and stress-rupture bars, valve seats, and short tubular shapes. When the 12-in. tensile bar was made it was longer than could be handled in our sintering furnace, so two half-sintered bars were sintered and then fused or welded together by grinding the two ends, placing a very thin sheet of nickel foil between them, and then heating the bars to around 1900° F. It was barely possible to detect the welded zone under a metallographic microscope.

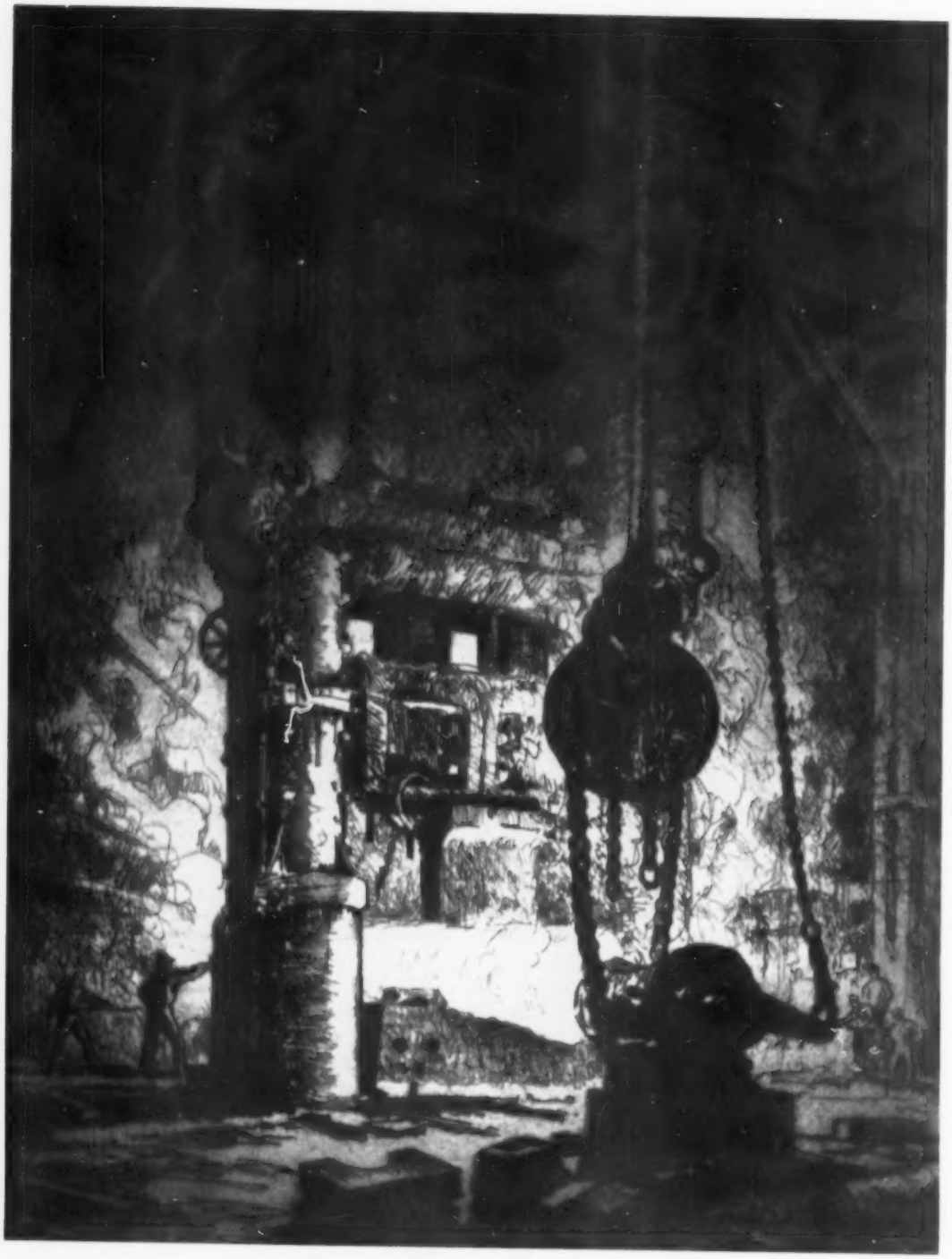
The FS-8 wheel shown in Fig. 10 was made by the method described earlier in the paper. The photograph shows it as it came out of the sintering furnace.

We also have made solid sintered disks of FS-27 in which the paddles were cut by the Method X or electric spark process, which can rapidly cut accurate and intricate shapes in materials that are not ordinarily machinable. This FS-27 wheel was spun at 36,000 rpm. for 50 hr. at a temperature of 1350° F. The wheel showed no signs of failure and so the temperature was increased to 1600° F. After spinning for 50 more hours the wheel showed no signs of failure and the test was discontinued.

Cermet parts may be sectioned or cut apart by a cut-off wheel. A long bar may thus be sintered and then sectioned into a number of small pieces. The type of wheel which was found best was a Carborundum Aloxite Resoid bonded wheel, A30-P-B3.

A nondestructive test for locating cracks is the fluorescent penetrant inspection. It is a sensitive way of locating minute discontinuities open to the surface. It consists of applying fluorescent liquid penetrant which enters into the cracks, removing the surface excess, and viewing by black light minute amounts of penetrant seeping back out from the discontinuities.

In conclusion, it should be mentioned that cermets with a variety of properties can be made by powder-metallurgy methods. Their oxidation resistance and their stress-rupture strength are excellent. The limiting factor to their use today in jet engine applications is their low impact resistance.



Current Studies of Large Forgings*

By A. O. SCHAEFER†

An outline of current studies under auspices of the American Society for Testing Materials, jointly by large forging makers and manufacturers of power-generating machinery, to find the cause (and cure) of brittle fracture and establish inspection methods whereby potentially dangerous forgings can be identified. (Q 23, Q 26, S 13, S 22, AY)

SPECIFICATIONS for steel products as well as the methods of testing and inspecting steel products are entrusted by the American Society for Testing Materials to Committee A-1. This is the oldest and one of the largest technical committees of the Society. Responsibility for specifications for steel forgings rests in Subcommittee VI of that parent Committee A-1.

It was only natural that the failures of large rotor forgings (described at some length in *Metal Progress* for February) should have repercussions in this A.S.T.M. Subcommittee, and at a meeting in January 1955 a task force under the author's chairmanship was appointed to "study the cause of brittle fracture in steel forgings with the aim of establishing a criterion by means of which the tendency of a material to fracture in a brittle manner may be appraised, and also to discover the causes of brittle fracture and investigate its cure".

This task force comprises representatives of eight companies — three manufacturers of electrical equipment and five manufacturers of large forgings for turbines and generators. This represents all of the makers and the users of large forgings of this type in the United States. The task force has met monthly since it was formed. Partial meetings were held during the Joint Metallurgical Societies Meeting in Europe in the spring of 1955.

It would be well to set the stage by describing briefly some of the work of A.S.T.M. Subcommit-

*The text is adapted from "The Work of the Task Group on Brittle Failure of Steel Forgings", contributed to the American Society of Mechanical Engineers' Annual Meeting in Chicago, Nov. 14, 1955. Published by permission of the A.S.M.E.

†At the time this report was written Mr. Schaefer was vice-president and executive assistant of the Midvale Co. At present he is director of research for Midvale-Heppenstall Co. of Philadelphia. He is also currently president of the American Society for Metals.

tee VI of Committee A-1. But first it is important to realize that the manufacture of turbine and generator rotor forgings has, throughout the years, been subject to constant review, and has been changed and improved with the growth of metallurgical and engineering knowledge and experience. It is safe to say that this product has commanded the attention of our best talent, and represents the finest practice that the industry knows of. The excellent record of our units substantiates this. The new factor, introduced by the Task Group on Brittle Fracture, is the correlation of thinking and experience to the end that our development may be more rapid.

The foundation for the work on brittle failure of forgings was laid during the last war. Conservation of alloying metals in forgings for steam turbines, generators, and related equipment was extremely important. Prior to the war, all forgings were purchased to conform to company specifications, and these contained many special features, the work of a number of individuals working separately. It was difficult for all manufacturers of electrical equipment, and all suppliers of forgings for such equipment, to reach agreement on material specifications, but the miracle was performed after much hard labor, and with utmost cooperation. The resulting "Emergency" specifications were published by A.S.T.M., and found their way as such into the Book of Standards. At the close of the war it was suggested that they be discontinued, but they were retained largely because they represented so much work. They have been kept up to date by frequent revision. There is no suggestion now of deleting them from the A.S.T.M.'s Book of Standards. Forgings made to these specifications are in successful service in thousands of power units throughout our country. More will be said about the matter of chemical composition of large forgings later in this report.

Tests – The quality of all commercial products is judged by sampling and testing methods, acceptable both to producer and consumer. Heavy forgings are no exception to this rule.

In 1953, the steel committees of the A.S.T.M. (subcommittees of A-1) revised the methods of making mechanical or physical tests for their products, and a new "Method" was prepared for the Book of Standards incorporating all current methods of testing. This is entitled "Tentative Methods and Definitions for Mechanical Testing of Steel Products" and is A.S.T.M. designation A 370-54 T – a 32-page document. However, it has resulted in an important misunderstanding. A large segment of the forging industry considered it correct to stress-relieve tension test specimens after they had been removed from the forgings they represented. This practice was challenged by others, and it was stated that the low-temperature heat treatments given these test specimens couldn't possibly remove stresses, but did remove hydrogen, with consequent improvement in ductility.

Hydrogen – The present interest in hydrogen in steel forgings originated from this discussion, and Subcommittee VI appointed a Task Group on Hydrogen in January 1953 charged specifically with "studying the problem of hydrogen in steel forgings" and with "advising Subcommittee VI when it should become advisable to take cognizance of the effects of hydrogen by suitable alterations in specifications".

This Task Force on Hydrogen has been extremely active. It first compared various laboratories' determinations of hydrogen, and found extreme variations. For example, determinations by six laboratories of hydrogen content of portions of a single forging were as follows:

Laboratory	Hydrogen Content, by Volume			
1	0.57	0.50	0.46	
2	0.94	0.91	1.03	0.73
3	0.46	0.48		
4	0.63	0.62	0.62	
5	0.66	0.67		
6	0.61	0.67	0.58	

Obviously, methods of sampling and analysis should be standardized, and a tentative specification is now being processed by the appropriate A.S.T.M. subcommittees.

Collateral studies of the effects of hydrogen are under way. Extensive tests have been made of test specimens which were or were not aged after removal from forgings. Data from one alloy steel indicate that the ductility in tension varies inversely as the hydrogen content. However, this conclusion is not substantiated by tests on other alloy steels. This discrepancy is under further investigation using various alloy steels.

A review of the literature, as well as actual data, indicates that hydrogen has no effect on notched-bar impact test results. This, too, is being investigated by the Task Force on Hydrogen. It is now working in parallel with the newer Task Force on Brittle Failure. Other organizations, notably the Forging Manufacturers Association Technical Committee and the Acid Openhearth Research Committee have collaborated.

Work on Brittle Failure

Subcommittee VI's Task Force on Brittle Failure has sought to rationalize the rather broad charter under which it came into existence into three main headings:

I. To discover a test to determine whether or not a steel is subject to brittle failure, or its relative susceptibility to brittle failure.

II. To attempt to make rotors less susceptible to brittle failure:

A – By heat treatment

B – By chemistry

C – By vacuum pouring techniques

III. To develop methods of inspection and of interpretation of inspection to avoid brittle failure of forgings in service.

Test for Brittleness – At the outset it was realized that it is possible to set up a stress pattern in any piece of steel that will cause it to fail in a brittle manner. The importance of design cannot be overemphasized. However, design is outside of the scope of this task force, and its importance is pointed out solely that it may be recognized.

The best of steelmaking practice goes into the manufacture of turbine and generator rotor forgings. However, metallurgical and mechanical irregularities become of increasing importance at levels of high strength, and the utmost in resistance to brittle failure is required when irregularities exist at such high levels.

It is obvious that the usual tension and notched-bar impact tests do not give sufficient information to appraise entirely the tendency of a steel forging to brittle failure. Poor ductility and low impact values are indicative of brittleness, but good ductility and high impact values do not necessarily mean that the material cannot fail in a brittle manner under certain combinations of circumstances.

(The problem is somewhat analogous to that faced by the forging industry in the manufacture of highly stressed gun barrels during the last war. All barrels show incipient cracks in the form of heat checks in the bores after a few initial rounds. In gun barrels the problem was to find a steel, or a condition of the steel, in which these incipient cracks do not progress too rapidly.)

The Task Force is now collecting data on two methods of testing, hoping that they may provide indications of the tendency of forgings to brittle failure.

The "transition temperature range" – in which the results of notched-bar impact tests fall off rapidly – may be an answer to this question. Rotors now in process have been tested to determine what this range is, or should be. The type of data is illustrated in Fig. 1, from Bethlehem Steel Co. Note that the foot-pounds of energy needed to break the standard V-notch Charpy specimens at various temperatures is supplemented by an observation of the nature of the broken surface wherein the percentage of granular and percentage of fibrous fracture are estimated. In this forging a completely fibrous fracture changes into one which has two-thirds granular fracture when the test temperature falls from 210 to 120° F., whereas the "impact strength" drops a relatively small amount in that same range.

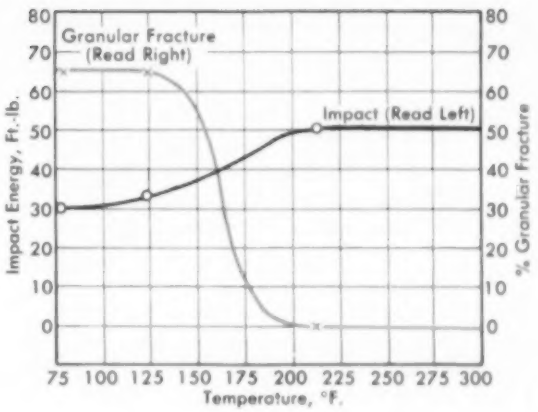


Fig. 1 – Temperature "Transition Curves" of a Ni-Mo-V Rotor Steel

Data are also being obtained on notched-bar bend tests, made on specimens removed from the forgings, machined in several sizes, notched, and bent to fracture as simple beams. The *unit* breaking load always decreases as the cross section of the specimen increases. If the results of such tests are plotted, using a logarithmic scale for the specimen size only, approximately straight lines result, as shown in Fig. 2. Possibly the slope of this line may be correlated with the property we are trying to measure; the more nearly horizontal the line, the less sensitive the steel is to stress concentrations, and the lower is its transition temperature range for notched-bar impact tests.

Both of these tests (the transition-temperature range for notched-bar impact tests, and the multiple size notched-bend test) require a number of accurately machined specimens and considerable

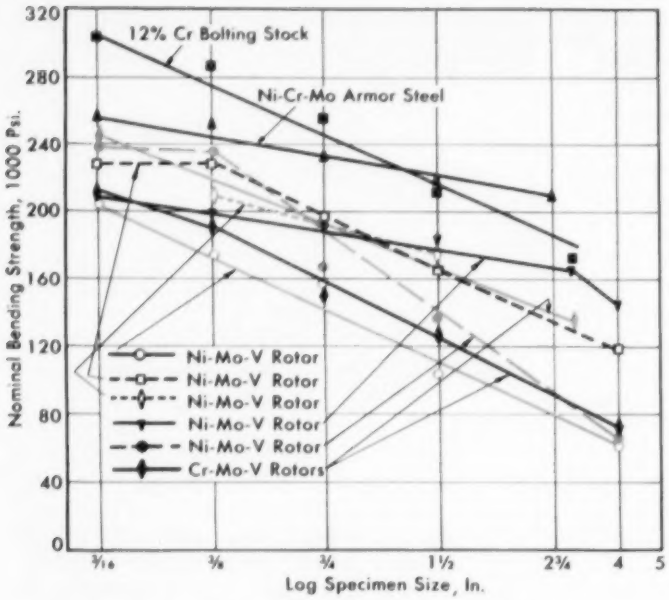


Fig. 2 — Influence of Size on Notched Bending Strength of Square Test Bars From Various Ni-Mo-V Rotor Forgings (and One Cr-Mo-V Rotor). 45° notch, 0.003-in. bottom radius, depth equals 20% of piece. Plotted by General Electric Co.

test metal. It does not seem that either gives us the whole answer. So the Task Force is looking for other and better criteria. Among those mentioned are (*a*) brittle-to-ductile transition-temperature tests along the lines developed by Pellini at the U.S. Naval Experimental Station, (*b*) the development of true grain outline by etching techniques, and (*c*) tear tests of specimens with incipient cracks.

Attempts to Make Rotors Less Susceptible to Brittle Failure

By Heat Treatment — European practice in the manufacture of turbine and generator rotors sometimes employs liquid quenching in heat treatment. Manufacturers there usually express a limitation in willingness to quench on the basis of diameter, or total mass, or total alloy content. American practice has been based on cooling in air only, with liquid quenching definitely forbidden because of the danger of cracking, instability, and residual stresses. This was substantiated by the failure of a quenched rotor at Canton, China, about 25 years ago.

Nevertheless, the Task Group is re-examining this position. Liquid quenching, if it can be done properly, is known to benefit the metal structurally and in its resistance to brittle failure. Fortunately the forging industry in the U.S. is now equipped to liquid-quench rotors should it be found beneficial.

Experiments have been carried out on rotor forgings which have been rejected for one reason or another. Preliminary reports indicate some beneficial effects on properties as measured in the conventional way, but there are also indications that the benefits are only to the surface metal, and will not extend to sufficient depth to be of real advantage. Rotors are now being quenched with buried thermocouples in all sections to record the actual rates of cooling at these points.

By Chemistry — The most common alloy steel used in rotor manufacture in the United States is the nickel-molybdenum grade containing about 2.75% nickel, 0.50% molybdenum, and 0.05 to 0.10% vanadium. This alloy steel commonly contains less than 0.20% chromium. A similar steel with a higher chromium content has been used for the higher strength requirements.

An entirely different steel with chromium, molybdenum, and vanadium has been used for several steam turbine rotors operating at moderately high temperatures.

The Task Group has to date devoted its attention to the larger rotors for low-pressure steam units or for the generators. Grades other than those mentioned above have been used for the smaller forgings used for high-pressure steam units.

A greater variety of steels is used in Europe. Rotors of European design are not stressed as highly as ours, and they still find extensive use for carbon steel as well as higher-chromium steels on the basis that they have great uniformity of properties in large sections.

American rotors requiring the highest level of tensile properties are usually made of a modified nickel-molybdenum steel, but European grades almost invariably contain lower nickel and quite definitely higher chromium than ours. A typical European steel contains about 2% nickel, 1.25% chromium, 0.40% molybdenum, with or without vanadium.

In planning the rotors for liquid quenching in a developmental program, some forgings will be made of the European analyses just mentioned and some of an alloy with still higher hardenability which might be usable if larger sections can be quenched effectively. Such test forgings are now being made.

By Vacuum Pouring – Vacuum melting of steel has been a tremendous aid in obtaining desired quality in the superalloys used for gas turbines and jet engines. (Such forgings have been quite small in comparison with those under review by the Task Force.) In December 1954 it became known that Bochumer Verein in Germany's Ruhr Valley was equipped to pour large ingots in vacuum.

The idea of pouring heats in vacuum was described first as a means of avoiding "flakes". The basic openhearth and basic electric furnace steel made in Germany is more susceptible to such defects than acid openhearth steel. It was stated that Bochumer Verein had succeeded in markedly decreasing the incidence of flakes by the new pouring technique.

This in itself is a worth-while achievement. However, if we note that the Hydrogen Task Group was started on its course because of the difference in test results obtained *after* hydrogen had been removed from the test pieces, we will realize that the vacuum pouring technique may be a possible means of improving inherent ductility and toughness.

Efforts were made by both forging manufacturers and users to purchase material poured in vacuum at Bochum, so that it might be compared with our domestic product. One electrical equipment manufacturer has succeeded in placing an order for rotors with that firm, but delivery is not expected before late in 1956. Bochumer Verein has consistently been unwilling to sell ingots, but has accepted an order for billets from one forging manufacturer. We must examine this material if we are to know whether or not the process has resulted in any improvement other than the reduced susceptibility to flakes.

No data have been made available by the Germans which would indicate how much hydrogen (or other gases) has been removed from the metal, but they have promised to divulge the information they have at a technical meeting in Germany in October of this year (1955).*

*Since this article was written, representatives of Bochumer Verein, speaking in the United States, have supplied some of these data.

Interpretation of Inspection

Rotors have been inspected by making use of tension tests, notched-bar impact tests, microstructure, Magnaflux, bore inspection, heat indication, and ultrasonics. This is the very practical side of the work of the Task Group.

We have undoubtedly not yet reached either a full understanding of ultrasonic inspection or the limit of its usefulness. The Task Group is therefore formulating inspection and testing procedures for the ultrasonic examination of rotor forgings with a view toward establishing acceptance standards. The basis for this has been agreed upon and a draft is now in preparation. The results of this work should be of great importance in establishing acceptance levels for the future.

Conclusion

The above is only an outline of the work of the Task Group on Brittle Failure of Steel Forgings and the program on which it is embarked. The understanding of the causes of brittle failure in forgings, and the control of it, are being given the attention of our best engineers and metallurgists. Everyone wants progress. We must be sure of our materials as we go along. The Task Group, having met immediate demands upon it, has now initiated a program of research to explore the fundamental aspects of the phenomenon of cracking.

A task group such as this is of unique importance in studying large forgings. Examples for study are large and expensive, and therefore few in number. It is important that the methods of examination in different laboratories be similar, so that data can be correlated.

The monthly discussion within the group has stimulated thinking, has brought out ideas and encouraged action. The program is a very large one, ranging from laboratory investigations of test methods to the trial of different methods of manufacture, and to an intensive search for the right inspection techniques.

It is only just to point out the fine record of American turbines and generators and the steel forgings that are in them. For many years we have been entirely free of major accidents. The spirit of cooperation that has and does exist in this industry between steelmaker and equipment manufacturer has established a fine record. The Task Group is a concentrated manifestation of this spirit.

Mechanical Properties of Medium-Carbon Boron Steels

*By J. R. KATTUS and C. L. DOTSON**

The tensile, fatigue, impact and notched-tensile properties of tempered medium-carbon boron steels are equivalent to those of other low-alloy steels tempered to the same hardness levels. (Q general, AY)

A MINUTE amount of boron can increase the hardenability of steel as much as several hundred times its weight in other alloying elements such as chromium, nickel and molybdenum. Boron's effect on hardenability has been thoroughly investigated and publicized, but few data have been available on the mechanical properties of commercial medium-carbon boron steels. Since such alloys have possible application in military aircraft, this investigation was sponsored by the Wright Air Development Center.

Two heats of each of the alloys 81 B 40, 98 B 40 and 81 B 30 were tested. The percentages of major alloying elements were near the high limit of the specification in one heat and near the low limit in the other. The test results, therefore, should show the spread in properties to be expected with allowable variations in the chemical composition of the alloys. The various heats are designated in this paper by the letters h and L, for high and low chemistry, respectively, following the alloy number; for example 81 B 40 h designates the high-chemistry heat of 81 B 40 alloy. The analyses are listed in Table I.

This investigation was limited to samples which had been fully hardened by oil quenching, and tempered 2 hr. in the range 600 to 1200° F. All test samples were machined from 1¼-in. diameter bars which had been melted, hot rolled and annealed in a commercial steel mill and subsequently normalized. Normalizing temperatures were 1600° F. for 81 B 40 and 98 B 40 and 1650° F. for the 81 B 30. Test specimens were machined 0.010 in. oversize from the normalized stock and finish machined after quenching and tempering.

Hardenability bands obtained from Jominy

*Mr. Kattus is Senior Metallurgist, Southern Research Institute, Birmingham, Ala., and Mr. Dotson is Metallurgist, Youngstown Sheet and Tube Co., Youngstown, Ohio.

Table I – Compositions of Test Heats

Heat	C	Mn	P	Si	S	Cr*	Ni*	Mo*	V*	Ti*	Al*	Zr*	B*
81 B 40 h	0.46	0.93	0.008	0.25	0.028	0.55	0.30	0.15	0.005	0.060	0.039	0.010	0.0016
81 B 40 L	0.39	0.66	0.008	0.26	0.038	0.34	0.27	0.11	0.004	0.044	0.035	0.008	0.0010
98 B 40 h	0.42	0.82	0.007	0.27	0.007	0.96	0.95	0.24	0.045	0.050	0.032	0.009	0.0010
98 B 40 L	0.35	0.75	0.006	0.26	0.010	0.85	0.69	0.17	0.024	0.054	0.033	0.008	0.0011
81 B 30 h	0.34	0.93	0.010	0.25	0.009	0.52	0.26	0.16	0.010	0.036	0.038	0.008	0.0009
81 B 30 L	0.27	0.73	0.012	0.26	0.010	0.39	0.20	0.12	0.009	0.039	0.032	0.008	0.0010

*Spectrographic analyses.

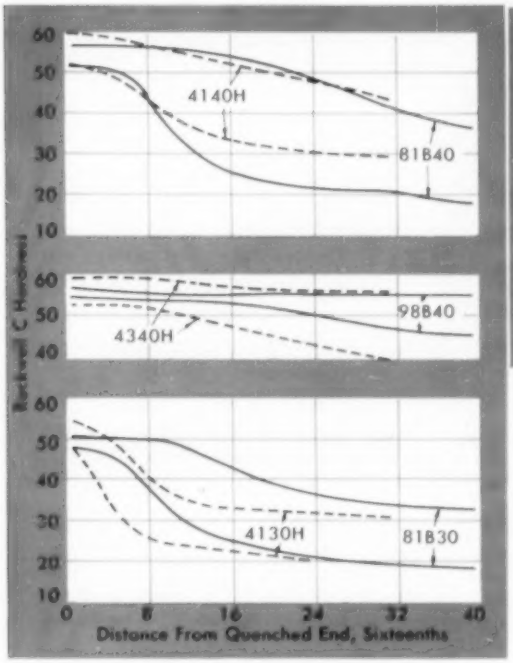


Fig. 1, 2 and 3 – Hardenability Bands for Three Boron Steels Compared With Standard S.A.E. Steels That They Might Replace

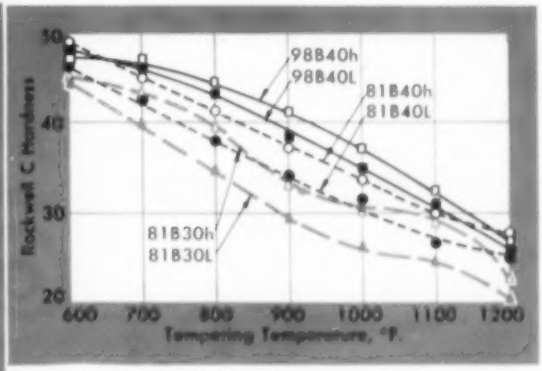


Fig. 4 – Effect of Tempering Temperature on the Hardness of Three Boron Steels

end-quench tests on the high and low-chemistry heats of each alloy are shown in Fig. 1, 2, and 3. For comparative purposes, the hardenability band for the standard S.A.E. steel which the boron steel might be expected to replace for some applications is also shown by the dashed lines. The quenching temperatures for all tests were: for 81 B 40, 1600° F.; for 98 B 40, 1550° F.; and for 81 B 30, 1650° F. Preliminary Jominy tests indicated that these austenitizing temperatures produce the best hardenability.

The effect of tempering temperature on hardness is shown in Fig. 4. In general, the 98 B 40 alloy is hardest at any particular tempering temperature. Undoubtedly this is because 98 B 40 contains the largest amount of the carbide-stabilizing elements chromium and molybdenum.

Most low-alloy steels have strikingly similar tensile properties when fully hardened and tempered to the same hardness level. With a few minor exceptions, the tensile properties of the boron steels fall remarkably well within the previously established limits for low-alloy steels, indicated by the shaded areas in Fig. 5, 6 and 7. Each of the points shown is an average of at least three tests. The tensile and yield strengths of 81 B 40 and 98 B 40 are slightly low and the yield strength of 81 B 30 slightly high at low hardness levels. At high hardness levels the reduction of area of 81 B 30 is somewhat high. The reduction-of-area data show that, at the higher hardness levels, this property tends to be higher in the low-chemistry heats.

Fatigue properties of both smooth and notched boron steel specimens at various hardness levels were determined. All of the fatigue tests were carried out on rotating-beam testing machines. The smooth specimens had a minimum diameter of 0.250 in. and a contour radius of 5 in. Notched specimens were 0.350 in. in diameter with a 60° notch. The diameter at the base of the notch was 0.250 in.; the bottom radius was 0.010 in.

Previous investigations of fatigue properties of

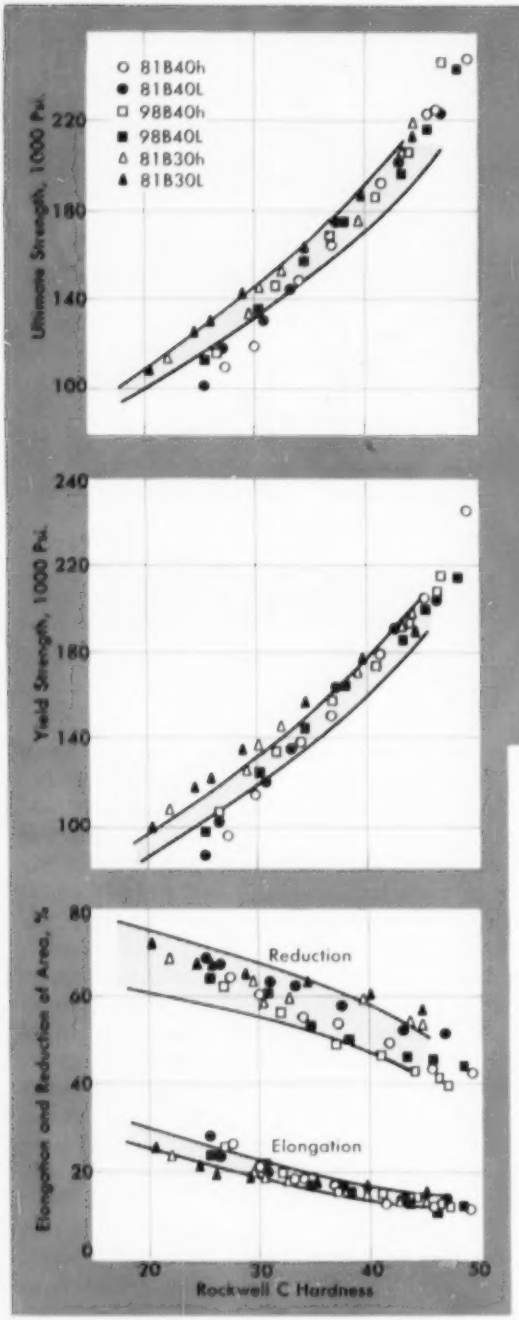


Fig. 5, 6 and 7 — Tensile Strength, Yield Strength and Ductility at Various Hardness Levels for Both High and Low-Hardenability Heats. For comparison, ranges for other quenched and tempered low-alloy steels, as determined by other investigators, are indicated by the shaded areas

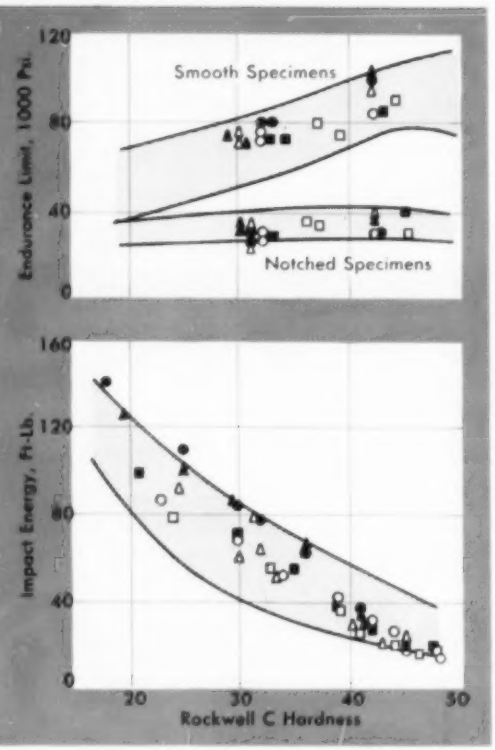


Fig. 8 and 9 — Endurance Limits and Room-Temperature Charpy V-Notch Impact Energy of Three Boron Steels at Various Hardness Levels Compared With the Ranges for Other Quenched and Tempered Steels (Shaded Areas)

quenched and tempered low-alloy steels have shown definite relationships between endurance limit and hardness. These relationships, in general, show more scatter than those for tensile properties but the results obtained by the various investigations are remarkably similar.

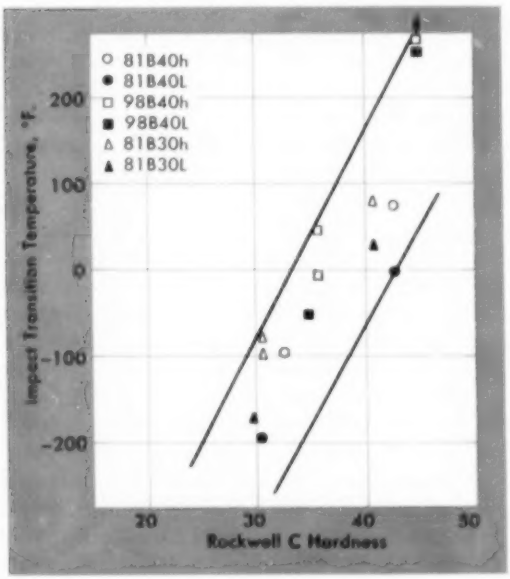
The endurance limits of the boron steels are plotted in Fig. 8 along with the ranges of endurance limits for many other steels. The endurance limits for the boron steels, in general, fall within the ranges previously determined for low-alloy steels at equivalent hardness levels. Smooth boron steel specimens have endurance limits equal to approximately one-half the ultimate tensile strength, which is normal for quenched and tempered steels. Notched endurance limits are, of course, affected by the size and shape of the notches and the resulting stress-concentration factors. The lower endurance limit range in Fig. 8 applies to severely notched specimens some-

what similar to those used in this investigation.

Room-temperature impact properties of hardened and tempered steels, which have not been embrittled in tempering, are a function of hardness. The relationship between impact resistance and hardness is not as consistent as that for tensile properties, probably because of the greater influence of such factors as cleanliness, grain size and directionality on impact properties. The Charpy V-notch impact resistance of the boron steels at different hardness levels is shown in Fig. 9 along with the range for a large number of quenched and tempered low-alloy steels.

The low-chemistry heats of each boron steel had better impact resistance than the high-chemistry heats especially at the lower hardness levels. A reduction in carbon content, and the corresponding lower tempering temperatures required to produce equal hardness, sometimes improve impact properties in low-allow steels. Lower carbon content, however, is apparently not the reason for the superior impact resistance of the low-chemistry boron steel heats. If carbon content were the sole controlling factor, the 81 B 30 heats would have better impact resistance than the 81 B 40 heats since they are very similar in all constituents except carbon. These steels, however, are equivalent in room-temperature impact properties.

Fig. 10 — Charpy V-Notch Impact Transition Temperatures of Three Boron Steels at Various Hardness Levels



Charpy V-notch impact tests over a wide temperature range were run on each heat of boron steel tempered to two hardness levels. In order to determine susceptibility to temper brittleness, parallel tests were run on specimens which had been air cooled and oil quenched from the tempering temperatures. The impact properties of the air-cooled specimens were equivalent to those of specimens oil quenched after tempering, thus indicating little, if any, susceptibility to temper brittleness at these cooling rates.

The impact test specimens showed, rather consistently, a change from fibrous to crystalline fracture at energy levels between 20 and 30 ft-lb., so 25 ft-lb. was defined as the transition energy level. Transition temperatures are plotted in Fig. 10 as functions of hardness. There is a scattered, but essentially linear, relationship of increasing transition temperature with increasing hardness. Transition temperatures were appreciably lower in all low-chemistry heats than in the corresponding high-chemistry heats at similar hardness levels.

Low-temperature impact properties and transition temperatures in steels are greatly affected by many variables in addition to hardness. Such factors include composition, grain size, deoxidation practice and cooling rate after tempering. A general comparison of the transition temperature of the boron steels with other low-alloy steels on the basis of equivalent hardness levels, therefore, is not feasible. Most tempered martensitic steels, however, have transition temperatures or start decreasing in impact resistance in the range −25 to −100° F. The non-temper-brittle low-alloy steels in the S.A.E. 2300, 4000, 4100, 4300, 4600, 8600 and 8700 series are recommended for use in this temperature range. On the basis of the transition temperatures shown in Fig. 10, 81 B 40, 98 B 40 and 81 B 30 also fit into this category when tempered to hardnesses of approximately Rockwell C-30 and below.

Notched tensile tests were run on each alloy after it had been quenched and tempered at temperatures from 600 to 1200° F. The test specimens were similar to standard 0.505-in. diameter tensile test bars except that the center of the gage length had a 60° notch with a 0.10-in. radius at the base. The original cross-section area was reduced 50% by the notch.

The average results for five medium-carbon, non-boron, low-alloy steels similarly notched are compared with the notched-tensile properties of the boron steels in Fig. 11 and 12. The ratio of

notched ultimate strength to tensile strength of the boron steels is approximately 1.5 up to a tensile strength level of 180,000 psi. The ratio decreased sharply above this level. This relationship closely agrees with the curve for other low-alloy steels. Notched reduction-of-area values of the boron steels at various tensile strength levels are approximately equivalent or superior to the average results for the non-boron steels.

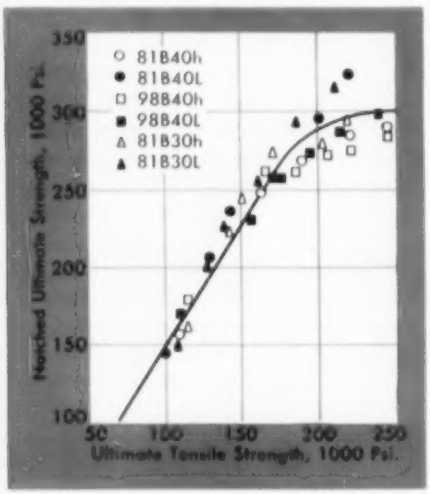
At equivalent tensile strength levels above 180,000 psi. the low-chemistry heat of each boron steel had higher notched ultimate strength than the high-chemistry heat. The low-chemistry heats also had superior notched reduction of area at all tensile strength levels.

Conclusions

The mechanical properties of the medium-carbon boron steels, 81 B 40, 98 B 40 and 81 B 30, when fully hardened and tempered within a range between 600 and 1200° F., compare favorably with the properties of other tempered martensitic low-alloy steels. At equal hardness levels from Rockwell C-20 to C-50, the tensile properties, endurance limits, room-temperature impact resistance, and notched tensile properties of the boron steels are equivalent to those of non-boron low-alloy steels.

Impact transition temperatures of the boron steels are in the same range as those of the non-temper-brittle S.A.E. steels. On the basis of Charpy V-notch impact test results, the boron steels can be recommended for use at temperatures as low as −100° F. when fully hardened and tempered to hardnesses of C-30 and less. The boron steels are not susceptible to temper brittleness when the cooling rates after tempering are no slower than the rates for air-cooled specimens.

Fig. 11 – Relationship Between Ultimate Tensile Strength and Notched Ultimate Strength of Three Boron Steels Compared With Average Curve for Other Quenched and Tempered Low-Alloy Steels



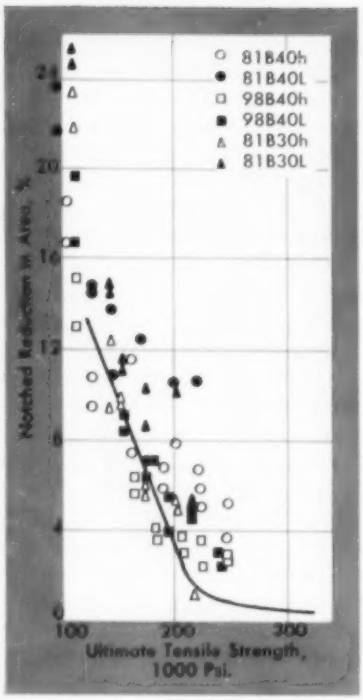


Fig. 12 – Relationship Between Ultimate Tensile Strength and Notched Reduction in Area of Three Boron Steels Compared With Average Curve for Other Quenched and Tempered Low-Alloy Steels

The high-chemistry heats of the boron steels have appreciably greater hardenability than the low-chemistry heats. The low-chemistry heats, however, consistently exhibit superior ductility and toughness properties at equal hardness levels in spite of the fact that there is no corresponding difference in strength. Notched reduction-of-area values and impact resistance were better in the low-chemistry heats than in the high-chemistry at all hardness levels.

Lower carbon content cannot be ascribed as the cause of superior ductility and toughness in the low-chemistry heats since these properties are equivalent in 81 B 40 and 81 B 30 in spite of the fact that the only major alloying difference is in carbon content.

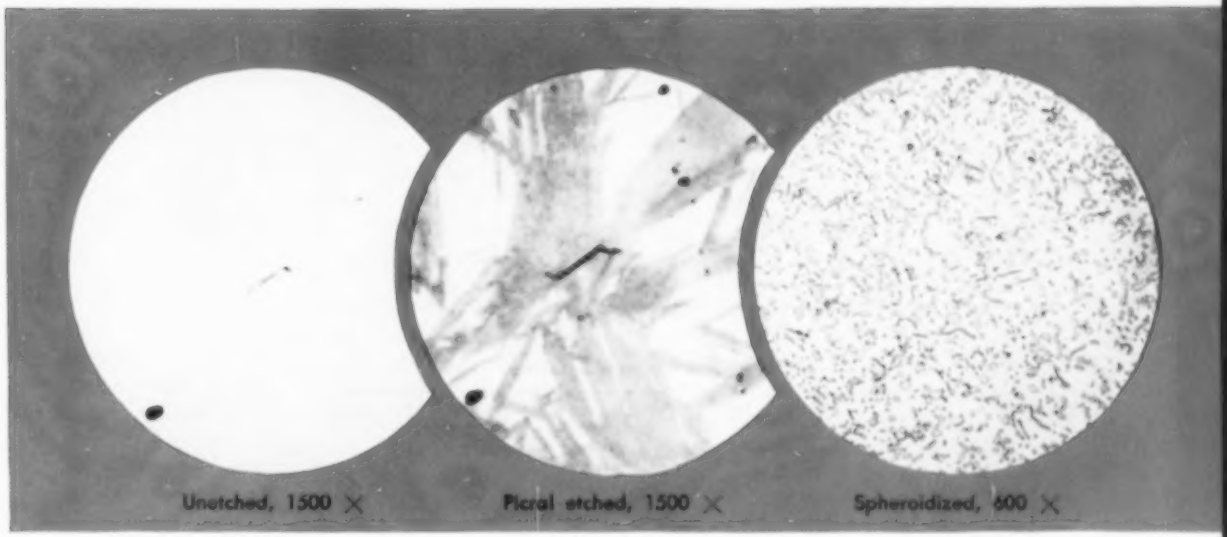


Fig. 1 – Silicon-Killed, Coarse-Grained Steel JDM 1022-FJ. Left and center represent conditions in case after carbo-nitriding 4 hr. total furnace time at 1650° F. and oil quenching. At right is same spheroidized at 1300° F. for 3 hr.; microcracks are still present.

Microcracks in Case Hardened Steel

*By A. H. RAUCH and W. R. THURTLE**

Microcracks occur in high-carbon steels or cases, in number principally dependent on the grain size established by heat treatment, and independent of quenching rate, alloy content, or method of carburizing or carbo-nitriding. (M 27, J 28, ST)

Microscopic cracks across the martensite needles of hardened high-carbon steel, or "microcracks", have been reported in the literature. H. S. Rawdon and S. Epstein observed them and published photographs in a scientific paper of the National Bureau of Standards in 1925. In 1931, Francis F. Lucas described them in his Howe Memorial Lecture "On the Art of Metallography" before the American Institute of Mining and Metallurgical Engineers. E. S. Davenport, E. L. Roff and E. C. Bain related their incidence to grain size in an article in *Transactions* of the American Society for Metals, Vol. 22, 1934, p. 289, entitled "Microscopic Cracks in Hard-

*When the work described was done, both authors were in the materials engineering department, Deere & Co., Moline, Ill. Mr. Thurtle is now with Boeing Aircraft Co. in Wichita, Kan.

Table I – Analysis of Steels Investigated

Element	JDM 1022-FJ	JDM 1018	JDM 1018-F	JDM 8620
Carbon	0.20	0.16	0.18	0.18
Manganese	0.91	0.75	0.72	0.82
Phosphorus	0.012	0.016	0.010	0.017
Sulphur	0.020	0.035	0.033	0.027
Silicon	0.20	0.002	0.20	0.26
Nickel	nil	nil	0.08	0.51
Chromium	0.02	nil	0.01	0.53
Molybdenum	nil	nil	0.01	0.24
Aluminum	0.002	nil	0.02	0.04

Table II – Grain Size at Quenching Temperatures

Treatment	JDM 1022-FJ	JDM 1018	JDM 1018-F	JDM 8620
As received	{60% 1 to 2 {40% 4 to 5	1 to 3	6 to 7	6 to 8
1650° F., 4 hr.	2 to 3	2 to 4	6	7
1.5 hr.	2 to 4	4	—	7 to 8
1550° F., 4 hr.	{15% 2 {85% 4 to 5	{20% 2 {80% 4 to 5	6 to 7	—
1.5 hr.	5	4 to 5	—	—
Reheated to 1450	5 to 7	5 to 7	7	7 to 8

ened Steel, Their Effects and Elimination". Nowhere in the American literature, however, has there been any report on microcracks in the high-carbon zones of case hardened steels.

In the materials engineering department of Deere & Co. we first noted their presence in the outer portion of the carbo-nitrided case of a gear made of JDM 1022 coarse-grained steel. Surface and corners spalled when the teeth were struck with a hammer. Our first reaction was that this condition resulted from carbo-nitriding. However, after a study of the literature cited above, we came to the conclusion that these microcracks might be a function of grain size and carbon content. If this were true, we theorized that microcracks should occur in the high-carbon portion of cases produced by carburizing – as well as carbo-nitriding – in coarse-grained steels, and we embarked upon a program to investigate the effects of case hardening processes, quenching severity, steel deoxidation practice and grain size on the incidence of microcracks. Typical microcracks are shown in Fig. 1.

The steels investigated included samples from mill heats of four steels currently in production, namely: JDM 1022-FJ (silicon-killed coarse-grained), JDM 1018 rimmed steel, JDM 1018-F (aluminum-treated fine-grained), and JDM 8620 (aluminum-treated fine-grained). Composition is shown in Table I, and McQuaid-Ehn grain size in Table II.

Effect of Grain Size and Quenching Severity – All four steels were pack carburized 4 hr. at 1700° F.; gas carburized 1.5 and 4 hr. at 1650° F.; carbo-nitrided 1.5 and 4 hr. at 1650° F.; and carbo-nitrided 1.5 and 4 hr. at 1550° F.

After each furnace treatment one set of samples was quenched into oil at 140° F. and another in 3% caustic solution at room temperature. Two sets of samples which had been pack carburized at 1700° F., gas carburized at 1650° F., and carbo-nitrided at 1650° F., were slow cooled and reheated to 1450° F. for grain refinement. One of these sets was quenched into oil and the other into 3% caustic. In all, some 24 heat treating programs were run on each of the four heats of steel.

In addition to the above, samples of the JDM 1022-FJ and the JDM 8620 steel were marquenched. These samples had been carbo-nitrided at 1650° F. for 4 hr., air cooled, reheated in cast iron drillings or neutral salt to 1650° F. and quenched into salt at 350° F.

All samples were tempered at 300° F. for 15 min. and examined at 1000 diameters for microcracks. The severity of cracking was recorded as the number of microcracks occurring in a 4.5-in. diameter field at 1000 magnifications. Counts of five such fields were averaged.

The grain size resulting from each high-temperature stay was determined by slow cooling from the furnace and rating the grain size in the hypo-eutectoid portion of the case. Results are shown in Table II. It will be noted that the shorter furnace times tend to result in a finer grain size with the JDM 1022-FJ and JDM 1018 rimmed steels and that reheating to 1450° F. produces a fine grain size in these steels.

From this mass of experimental data we have constructed Fig. 2.

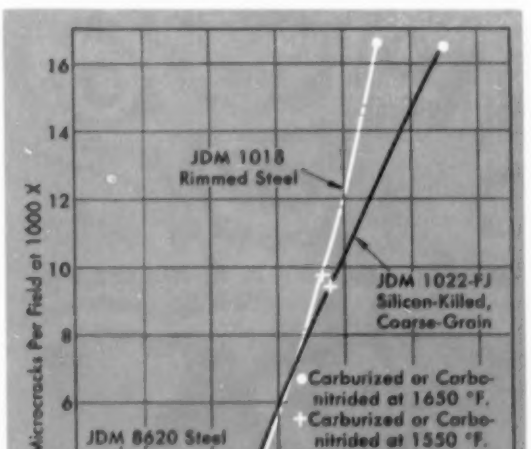
The frequency or number of microcracks per unit area and the size of the microcracks appear to be chiefly a function of the grain size established at the austenitizing temperature. The frequency of microcracks in the aluminum-treated steels JDM 1018-F and JDM 8620 was very low

– practically insignificant – and their size was small after austenitizing up to the grain-coarsening temperature.

In the other steels that were not aluminum treated (JDM 1022-FJ and JDM 1018 rimmed) the frequency of microcracks became greater and the size of the cracks increased as the grain size coarsened with increasing temperature. In both these "coarse-grained" steels the number of microcracks per unit area was only one to three per field at 1000 × on samples reheated to 1450° F. and quenched, wherein a grain size of 5 to 7 was established. However, the frequency increased to 12 to 16 microcracks per field at a carbo-nitriding or carburizing temperature of 1650° F., when the grain size grew to 2 to 4. Reducing the carburizing or carbo-nitriding time from 4 hr. to 1.5 hr. reduced the frequency of microcracks at 1650° F. but not at 1550° F. This was due to the grain growth at the longer holding time and higher temperature.

Figure 2 also shows that alloying elements, at least in the amounts of the 8600 series (0.5% Ni, 0.5% Cr, and 0.2% Mo) have no effect on the formation of microcracks upon oil quenching. Occurrence and severity appeared to be somewhat reduced in pack carburizing compared with gas carburizing and carbo-nitriding. For example, the two coarse-grained steels showed from 11 to 17 microcracks per field after carbo-nitriding or gas carburizing (both 4 hr. at 1650° F.) and direct quenching either into hot oil or a caustic solution. Pack carburizing these steels 4 hr. at 1700° F. resulted in 5.5 to 8.5 microcracks per field after the same quenches.

Fig. 2 – Summary of Counts Versus Grain Size



As long as the case is quenched to martensite, the occurrence and severity of microcracks are independent of the quench. Rate of quenching of these coarse-grained steels seemed to have no direct influence; in about half the tests, the averages of the microcracks per field were somewhat higher for hot oil quenching than in cold caustic; in the other half the situation was reversed. Quenching of the JDM 1022-FJ steel from 1650° F. into salt at 350° F. resulted in almost the same number of microcracks as either oil or caustic quenching.

Relation to Carbon Content – The frequency of microcracks is reduced with a reduction in the carbon concentration of the case. A sample of JDM 1022-FJ silicon-killed, coarse-grained steel was carbo-nitrided at 1650° F. in an atmosphere whose carbon potential was controlled to produce a slightly hypo-eutectoid case. The number of microcracks per field in the carbo-nitrided case of this sample was very low – 1 to 2.

Influence on Toughness – Izod impact tests, using round standard V-notched bars, were made on the JDM 1022-FJ silicon-killed, coarse-grained and the JDM 1018-F aluminum-treated fine-grained steel. The carbo-nitriding cycle used on the impact bars was: 1650° F. for 4 hr. total furnace time; oil quenched; tempered at 300° F. for 30 min. The bars were notched prior to heat treatment. Case depths were 0.022 in. The JDM 1022-FJ steel gave an impact value of 3 ft-lb. and had a grain size of 1 to 3 and 16 microcracks per field, whereas the JDM 1018-F steel gave 28 to 32 ft-lb. and had a grain size of 6 to 7 and 0.8 microcracks per field. However, the core hardness of the JDM 1022-FJ was lower than the JDM 1018-F – Rockwell C-27 to 30 compared with Rockwell C-17 to 18 – which also influenced the impact results. The last-mentioned steel, after grain coarsening to 70% No. 1, 30% No. 6 to 8 by heating to 1850° F., had an impact value of only 9 ft-lb. and 8.4 microcracks per field.

Somewhat different results were obtained from the alloy steel JDM 8620. Izod bars with 0.040-in. cases had impact strengths of 4 ft-lb. when grain size was 6 to 7, even though the microcracks in one group were 2.8 per field and in another group (double-quenched) were 13.0 per field.

The results, therefore, are inconclusive except

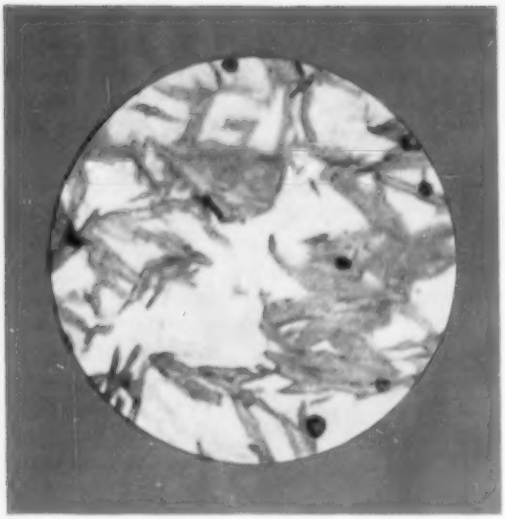


Fig. 3 – JDM 8620 Steel Heated to 2200° F. and Carburized at 1650° F., Oil Quenched, and Subsequently Reheated to 1650° F. and Oil Quenched. Note microcracks in the retained austenite areas formed from the original quenching of the coarse-grained steel, and the microcracks across the martensite needles formed by subsequent quenching from 1650° F. Saturated picral etch. 2000 ×

for the evidence that the effect of microcracks is minor in comparison with grain size in reducing impact strength.

Origin of Microcracks – Opinions have been expressed that microcracks are not formed in quenching but originate either as a result of sample preparation or as a result of the action of the acid etchant on the highly stressed martensite.

In order to determine whether or not sample preparation was responsible, a sample of JDM 1018-FJ, which had been carbo-nitrided for 4 hr. at 1650° F., was spheroidized by reheating at 1300° F. Figure 1 at right shows microcracks still in the matrix.

W. L. Jensen and R. F. Campbell in an article in *Journal of Metals*, September 1953, Vol. 5, p. 1222, entitled "Detection of Microcracks in Steel", demonstrated that microcracks are present in high-carbon coarse-grained martensite before etching. The microcracks were apparent after polishing both electrolytically and mechanically.

Microcracks seem to occur in the larger martensite needles. Grange and Stewart in *Transactions* of the American Institute of Mining and Metallurgical Engineers, Vol. 167, 1946, p. 473, show evidence that the first needles to appear are relatively large and seem to show a preference for austenite grain boundaries. If this be true, then, as the remaining austenite within the grains transforms to martensite, the stresses resulting from the volume change could account for the cracking of the initial large martensite needles. The coarser the austenite grains, the larger are the martensite needles. These larger needles would be more apt to crack than the small needles resulting from the transformation of small austenite grains. See also Fig. 3.

Conclusions

While the presence of microcracks in the martensite needles of high-carbon, coarse-grained steel has been known for some time, their presence in the high-carbon portion of carbo-nitrided or carburized cases has not, to our knowledge, been discussed previously in American literature.

The frequency or number of microcracks per unit area and the size of the microcracks appear to be chiefly a function of the grain size established at the austenitizing temperature. Deoxidation practice is important only insofar as it affects grain coarsening temperature and grain growth.

Quenching medium, whether 3% caustic solution, 140° F. oil, or 350° F. salt, has no effect on their formation. Microcracks occur if the steel is coarse-grained under the austenitizing conditions employed, regardless of the severity of quench.

The method of producing the case, whether carburizing or carbo-nitriding, also seems to have little or no effect, but pack carburizing appears to result in somewhat fewer microcracks.

Alloying elements, at least in the amounts present in 8620 steel, appear to have little effect.

It appears that the carbon content must be eutectoid or greater before microcracks appear.

Large amounts of retained austenite appear to reduce the number of microcracks, probably because transformation to martensite has not been completed and the stresses due to volume change are reduced.

We realize that this is far from being a complete or thorough investigation. We merely wish to call attention to this phenomenon since it might explain certain occurrences of failure. We would expect these microcracks to be harmful in applications where fatigue is involved or where spalling could result from high unit loads or impact loads. Where such conditions of service exist, it might be wise to make sure that the part is made of fine-grained steel.

The authors wish to express their appreciation to F. T. McGuire, manager, and C. W. Ray, metallurgical supervisor, materials engineering department, Deere & Co., for their counsel and guidance.

Stress-Corrosion Cracking of Stainless Steel

By G. KLINGEL*

Surface stress is often present in hardened stainless steel parts even after stress-relieving treatments. Removal of a thin surface layer after heat treatment can prevent stress-corrosion failures. (R1, S8)

WHEN stress-corrosion cracking occurs in stainless steel parts or equipment in service, it may be the result of a variety of factors including (*a*) selection of the wrong alloy for the corrosive medium encountered, (*b*) its condition of heat treatment or cold work, (*c*) improper processing in the fabricator's plant, and (*d*) stress in the surface of the metal. Surface stress is very important and is the cause of many stress-corrosion problems. A method of alleviating this fault was recently indicated by experiments performed in the Armco research laboratories.

Three 1¼-in. globe valve seat rings of Type 420 stainless steel had a number of cracks on all surfaces except the seat after service in 90-psi. saturated steam for about a year. Similar failures had been encountered before and had become evident only after fracturing or hot acid etching. In all instances, only the seat area was unaffected.

Two of the samples had been thoroughly etched in acid for examination before we received them, and had a network of fine fissures as shown in Fig. 1. The fissures covered all areas of the valve, including the threaded region, except for the tapered seat seen in the upper part of this illustration. The third sample was unetched and coated with a heavy scale. Very fine cracks were discovered beneath the scale at one end of the piece. Careful etching of this end with nitric-hydrofluoric acid partly removed the scale and uncovered a network of cracks similar in configuration to those of the other samples, but filled with scale or other oxide. It was left undisturbed for metallographic examination. Appearance of the partly descaled surface is shown in Fig. 2.

The two etched samples were too eroded to be of value in determining the cause of cracking by metallographic examination. However, the scaled, unetched sample showed many fine intergranular fissures filled with oxide to their farthest extremities, as shown in Fig. 3, indicating that the cracks formed either during the original heat treatment or during service in the steam line.

*Metallurgist, Armco Steel Corp., Baltimore, Md.

Fig. 1 – Etched Globe Valve Seat Ring With Fine Corrosion Cracks Over Entire Surface Except the Seat

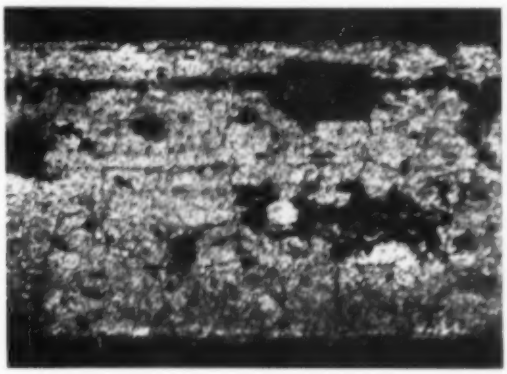


Fig. 2 – Scaled Surface of Seat Ring When Removed From Service

Fig. 3 – Stress-Corrosion Crack Filled With Oxide. Unetched. 200×

Fig. 4 – Stress-Corrosion Test Specimen

Here and there the intergranular penetration was complete enough that entire grains had fallen from the matrix. These cracks are similar to a number produced artificially in studies of stress-corrosion cracking in Armco's research laboratories.

Our problem was to determine where the stress came from, since the manufacturing cycle did include a stress-relieving heat treatment after finish machining and broaching. The parts were hardened by oil quenching from 1850° F., then stress-relieved at 800° F. for 2 hr. and air cooled. After heat treatment about 1/64 in. was machined from the diameter of the seat section; the rest of the part received no further work.

The injurious stresses seem to have been induced by the hardening quench and its effect on the surface metal, which was left in a state of stress. Although the valve parts were stress-relieved at 800° F., this treatment does not necessarily remove all hardening stresses at the surface and actually, under certain conditions, may introduce new and added stresses. This was indicated by the observation that there was no sign of cracking in the valve seat area which had had a small portion of the surface removed after heat treatment, thus artificially relieving, reversing or changing surface stresses at this point.

To prove the point, the Armco laboratories devised a test specimen of Type 420 stainless steel and subjected it to the valve manufacturer's sequence of hardening and stress-relieving. The test specimen consisted of a round bar 9¾ in. long by 1 11/16 in. in diameter. Before heat treatment portions of the surface were machined to simulate as closely as possible the various kinds of surfaces found on the faulty valve part. These included a threaded section, a rough-machined section, a finely finished machined section and a ground portion. The bar was then heat treated and a small part (about ¾ in. wide) of each section, except the threaded area, was refinished on a lathe. Approximately 1/64 in. was removed from the bar diameter at these segments. Following this, the entire specimen was subjected to a solution of 6% sodium chloride, 0.5% acetic acid saturated with hydrogen sulphide and the balance water, at room temperature for 19 hr. This solution is effective in determining tendencies toward stress-corrosion cracking in hardenable grades of stainless steel.

All sections cracked except those portions that had 1/64 in. of surface removed after heat treatment; such areas were free of faults as shown in Fig. 4. Repeated experiments with four separate test specimens produced the same results. It is significant that the characteristics of the cracks, when examined under the microscope, were identical in configuration and structure with those discovered in the faulty valve part. It is also noteworthy that the deleterious effects of hardening and stress-relieving as they are related to stress-corrosion, may, under certain conditions, be confined to a very limited surface area, sometimes very thin but sufficient to initiate stress-corrosion cracking which, once started, may proceed rapidly and catastrophically.

Stabilization of Aluminum Alloy Castings

By G. B. OLSON*

To obtain the precise dimensional tolerances required for instrument components, aluminum alloy castings are stabilized by treatment at both −150° F. and 450 to 475° F. Stabilization does not affect mechanical properties or corrosion resistance. (J 1, Al)

MANY aluminum alloy castings are used in computers, bomb director systems, cameras and other instruments manufactured by Norden-Ketay Corp. Practically all of them are 356 alloy (7.0% Si, 0.3% Mg) and used to be heat treated to the T 6 condition. Even though the instrument components must maintain dimensional stability during machining and in service, only a few castings were given the so-called stabilizing (T 71) treatment. Neither heat treatment is satisfactory for parts that require very precise dimensions.

Instruments have continually been made more complex and more compact so that we were faced with the problem of either improving dimensional stability of the castings or redesigning modified instruments completely. The stabilizing treatment would be used on 356-T 6 and would have to (*a*) increase dimensional stability during and after machining and (*b*) provide machinability, mechanical properties and corrosion resistance at least equal to that of 356-T 71. The standard heat treatments are listed in Table I. Resultant mechanical properties are:

	356-T 71	356-T 6
Tensile strength	33,000 psi.	28,000 psi.
Yield strength	24,000	21,000
Elongation	3.5%	3.5%

Complete relief of residual stress is never achieved in practical heat treatment of aluminum alloy castings since temperatures below 500° F. must be used to retain satisfactory mechanical properties. The problem is exaggerated in irregularly shaped castings with very thin sections adjacent to heavy sections because of the additional stresses provided by the hot water quench from the solution temperature which is usually specified.

Since higher temperatures could not be used for stabilization without adverse effect on the mechanical properties, we investigated a number of combinations of intermediate and subzero temperatures. The result of each treatment was evaluated by measuring the intensity of mechanical stress by X-ray diffraction. Some representative measurements are shown in Fig. 1; high residual stress is indicated by low, broadened

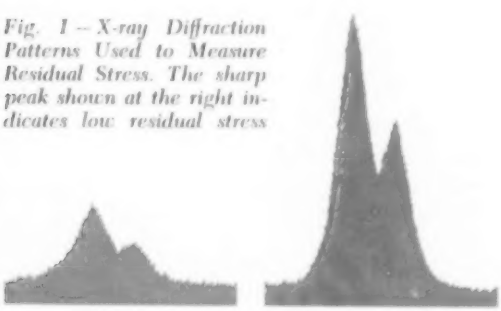


Fig. 1 — X-ray Diffraction Patterns Used to Measure Residual Stress. The sharp peak shown at the right indicates low residual stress

*Consulting Metallurgist, Instrument and Systems Div., Norden-Ketay Corp., Milford, Conn.

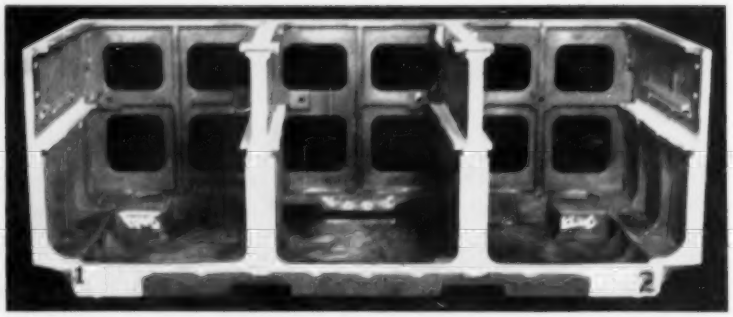


Fig. 2 — Computer Frame Casting

peaks; stress-free material produces the high, sharp peaks shown at the right.

Two stabilizing treatments have now been adopted, one for regular castings and the other for castings in which there are extreme differences in the thickness of various sections. More than 15,000 castings have been treated and their corrosion resistance, mechanical properties and dimensional stability have been completely satisfactory. One test specimen ⅝ × ⅝ × 31 in. that was stabilized and machined in 1952 has shown less than 0.00001 in. per in. deviation from a straight line.

The treatment usually used on 356-T 6 castings is 4 hr. at 450° F., 2 hr. at −150° F. and 2 hr. at 475° F. The casting is then rough machined to within 0.010 in. of the final dimensions, held at −150° F. for 2 hr., 475° F. for 2 hr. and then finish machined. Representative mechanical properties after this treatment are 30,800 psi. tensile strength, 23,400 psi. yield and 4.1% elongation.

Much of the residual stress in complicated castings results from the quench from the solution treatment. We have found that we can reduce the stress appreciably by "air quenching" rather than quenching in hot water. The slower quench has no measurable effect on either mechanical properties or corrosion resistance of the 356 alloy. We do not use an air blast but a moderate draft like the suction from a ventilating system. The complete cycle is: Solution anneal at 985° F. for 2 hr., air quench, age 10 hr. at 310° F., then 2 hr. at −150° F. and 2 hr. at 450 to 465° F. For parts that require extreme precision, the treatment at both −150° F. and 450 to 465° F. may be repeated prior to finish machining.

Table I — Standard Heat Treatments for 356 Alloy Castings

Treatment	Temp.	Time	Quench
Solution	1000° F.	12 hr.	Water at 150-212° F.
T 6 — Precipitation	310	3 to 5	air
T 71 — Stabilization	475	2 to 4	air

The rate of heating to the stress-relieving temperature and particularly the rate of cooling from this temperature must be controlled so as to minimize the stress-raising effect of temperature differentials. For example, the large 47½-in. long computer frame, shown in Fig. 2, increases ¼ in. in length when brought up to about 475° F. With fast cooling the thin-section side will contract much faster to normal length than the heavier side. In this instance it is necessary to introduce controlled cooling of about 100° F. per hr., by use of a cam-controlled pyrometer.

Section size is important since it determines the soaking time needed to insure that all parts of the casting are at the same temperature. This means that when a 2-hr. treatment is called for, timing should start after the heaviest section is at the temperature specified. This rule also applies to the subzero treatment.

Warping and distortion from the standard water-quench process are usually straightened at the foundry or after delivery of the castings. When this is done the casting may "remember" this treatment and creep back slightly even after stabilization. Therefore, it is better to re-heat treat using the "air quench" process. The straightening is done at 700 to 800° F., preferably before solution treatment. If, however, tolerances are not too close, straightening may be done cold, just prior to the 310° F. precipitation treatment.

Occasionally some castings may be finish machined without having had the proper heat treatment. With the air quench process it is possible to heat treat after finish machining. This, however, is not recommended as standard practice and should be resorted to only in emergencies and then requires most careful handling.

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Reduction of Area, %	50-45
Charpy V-Notch Impact, ft.-lb.	20-17
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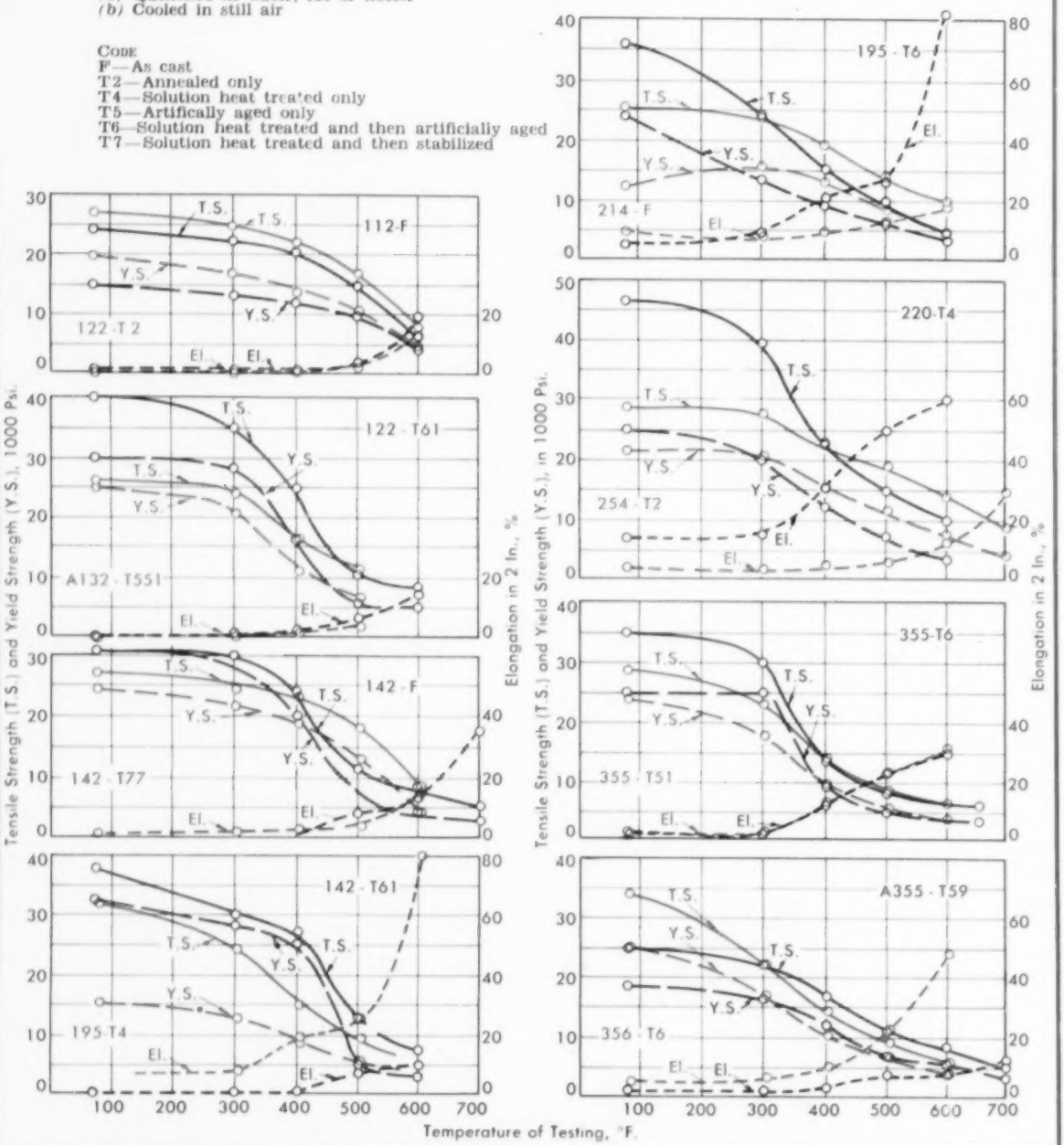
(Stabilized 10,000 Hr. at Temperature Before Testing)

Alloy	Nominal Analysis, %						Heat Treatments, °F.	
	Cu	Si	Mg	Ni	Mn	Zn	Solution Treatment T4	Aging or Stabilizing
112	7	—	—	—	—	1.7	—	—
122	10	—	0.2	—	—	—	12 hr. at 950 *(a)*	10 to 14 hr. at 310 for T61
A132	0.8	12	1.2	2.5	—	—	—	14 to 18 hr. at 340 for T551
142	4	—	1.5	2	—	—	6 hr. at 960 *(a)*	3 to 5 hr. at 400 for T61
195	4.5	—	—	—	—	—	6 hr. at 960 *(b)*	1 to 3 hr. at 650 for T77
214	—	—	3.8	—	—	—	12 hr. at 960 *(a)*	3 to 6 hr. at 310 for T6
220	—	—	10	—	—	—	—	—
254	—	—	6	1.5	1	—	16 hr. at 810	—
355	1.3	5	0.5	—	—	—	—	1 to 3 hr. at 650 for T2
A355	1.3	5	0.5	0.8	0.8	—	12 hr. at 980 *(a)*	7 to 9 hr. at 440 for T51
356	—	7	0.3	—	—	—	—	3 to 5 hr. at 310 for T6
							—	18 to 22 hr. at 440 for T59
							12 hr. at 1000 *(a)*	3 to 5 hr. at 310 for T6

(a) Quenched in water, 150 or hotter
(b) Cooled in still air

Code
F—As cast
T2—Annealed only
T4—Solution heat treated only
T5—Artificially aged only
T6—Solution heat treated and then artificially aged
T7—Solution heat treated and then stabilized



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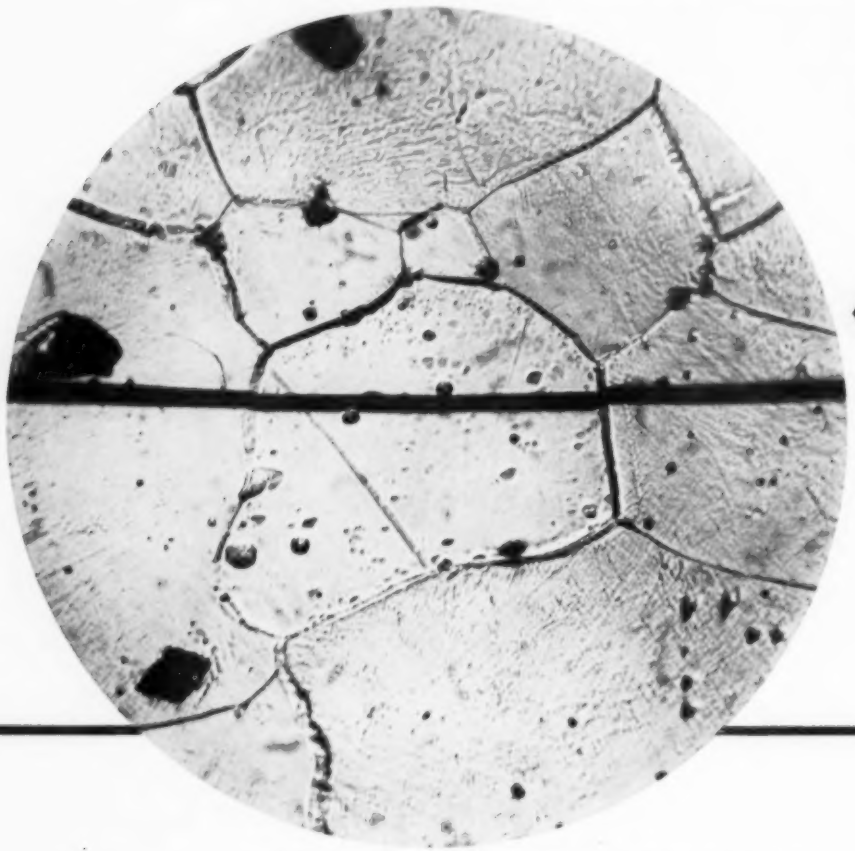

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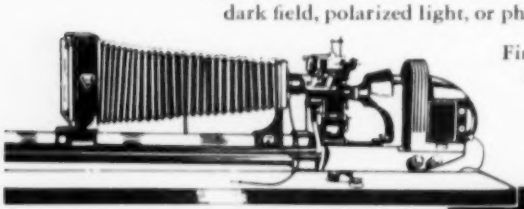

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SINCE B&L 1853

Fifty Years of Progress in Arc-Furnace Electrodes

*By F. B. O'MARA**

Arc-furnace steelmaking would be impossible without carbon and graphite electrodes. At each stage of advance in furnace design, electrodes of the necessary size and quality have been available. (D 5, C)

THE FACT that the year 1956 is both the 100th anniversary of the birth of E. G. Acheson and the 50th anniversary of the first United States electric-arc furnace for steelmaking is significant. The contributions that were made by Dr. Acheson to manufacture of carbon and graphite and the field of electrothermal phenomena made possible the arc-furnace electrodes we know today. Without carbon for electrodes, there would be no electric-arc furnace; without carbon's more refined form, graphite, it is questionable at just what point further development may have been retarded.

Actually, the arc furnace was conceived in 1880 by Sir William Siemens when he discovered that an arc could be used to melt metals in a confined space and that it would induce metallurgical reactions. A horizontal furnace using an indirect arc was designed in 1898 by Stassano, in Rome, for the reduction of iron ore. Paul Heroult first applied the direct arc principle to produce ferrochromium in France in 1899. Early in 1902, the first closed-top furnace for the production of steel went into operation.

The first furnace in the United States was also a Heroult, direct-arc, single-phase, three-ton unit operated in duplex with an openhearth. The electrodes used were carbon, square in cross section, the first of which were delivered with the furnace from France. Presumably more of these nonjoinable electrodes were imported from France, although some were imported from Ger-

*Electrode Product Sales, National Carbon Co., New York City.

many and Sweden during those early days. There were so many difficulties both with quality and delayed deliveries that it became imperative to develop a dependable American source.

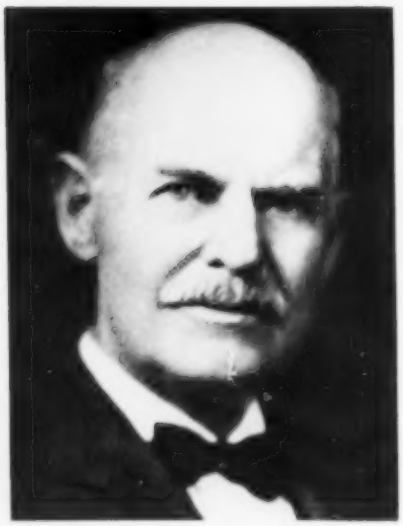
Fortunately even though the requirements of the infant arc furnace were not anticipated, electrodes of the necessary size and properties were already being produced in America by the flourishing carbon business. In 1906, National Carbon Co. was producing carbon electrodes as large as 8 in. in diameter and 48 in. long, made of fine-grained petroleum-coke material, and Acheson had already developed a method of joining electrodes to reduce stub loss and allow continuous furnace operation.

Manufacture of carbon products did not become commercially important until 1867 when the first practical dynamo was constructed, even though it was 1800 when Sir Humphrey Davy first made an electric spark jump between two rods of charcoal. Almost coincidental with Davy's demonstration was the discovery of Cruickshank that an electric current breaks down common salt into sodium and chlorine. Only minor (and for the most part, unsuccessful) efforts were made to utilize this new knowledge for several years because of the limitations of the voltaic pile battery, then the only known source of power.

In 1831 Michael Faraday discovered the principles of electrical induction, permitting the conversion of mechanical work into electricity. A short time thereafter, Pincinotti, Siemens, Wheatstone, Gramme and others began the development of the dynamo.

The first significant step in carbon development, after Davy's first use of charcoal as electrode material, came in 1846 when Staite and Edwards patented a process for making carbon electrodes from pulverized coke and sugar. The mixture was molded under high pressure and the shaped mass baked at white heat. The electrodes were then dipped in a concentrated sugar solution on the assumption that the sugar would enter the pores and make the mass denser after a second baking. This was, without doubt, the first attempt to impregnate carbon to improve its physical properties.

Lenolt went a step further in the same year. His prepared carbon consisted of two parts of retort carbon, two parts of wood charcoal and one part liquid tar. The materials were worked into a paste, kneaded, molded, pressed, covered with sugar syrup and subjected to a high temperature for 30 hr. or more. Lenolt also tried, but with limited success, to purify carbons by immersion in acids before baking. The acid treatment must have looked promising at the time because others continued the experiment.



Edward Goodrich Acheson (1856-1931)

By 1857 attempts were being made to purify electrodes by immersion in fused caustic soda or potash in the hope that the silica in the carbon might thus change to soluble silicates. After fusing, the electrodes were steeped in hot water and exposed to a current of chlorine gas in a porcelain tube. It was supposed that the various earths not affected by the soda or potash would be converted into volatile or soluble chlorides and a purer carbon would be produced.

At about this time the idea was conceived of making carbons of a mixture of lampblack, benzene and turpentine. This mass was kneaded, pressed and baked to produce a porous coke, since the benzene and turpentine volatilized during the baking. The porous product was then saturated with resins and rebaked in an attempt to increase the density.

Ironically, the "science" of making carbon electrodes was quite far advanced before anyone became concerned with the more logical approach of purifying the basic ingredients from which the shape was formed rather than attempting the complicated alchemy of changing or removing impurities from the finished piece.

Calcining of raw materials began with the heating of mixtures of resins, pitch and oils in closed vessels. The volatile products were condensed and collected for re-use. The carbon left over after the decomposition was pulverized and

mixed with lampblack; the condensed volatile products were used as binding material. The mixture was kneaded, molded in steel molds under hydraulic pressure and baked. The electrodes were considered superior to others in commercial use at the time.

From a commercial standpoint, the most conspicuous success in producing carbon was contained in a patent covering a carbon mixture consisting of 15 parts of very pure, finely pulverized coke, 5 parts of calcined lampblack, and 7 to 8 parts of sugar syrup. The powders were moistened either with syrups, gums, gelatine, or with fixed oils thickened with resins, to form a paste sufficiently plastic and consistent to be forced at about 100 atmospheres into cylindrical rods through a drawplate at the bottom of a powerful press. The rods were piled into retorts and baked at a high temperature to produce the first extruded electrodes.

Charles F. Brush, who later became associated with National Carbon Co., entered the field of practical and commercial electricity in 1876 with his version of the dynamo and a carbon-arc lamp in which the arc was controlled by current. The carbons Brush used in his first demonstration were sawed out of gas retort carbon, but very shortly he, in collaboration with W. H. Lawrence, his plant superintendent, used raw petroleum coke by pulverizing it, mixing it with a binder and molding to shape. Difficulties with densities led them to the invention of the process for calcining coke. Added to this important development was the invention of a hydraulic press which was the forerunner of those used today.

The uses of electrodes were becoming sufficiently broad to warrant the organization of companies devoted to their exclusive manufacture. The Cleveland Carbon Co. was formed by two partners, Crouse and Tremaine, in 1884. Their importance to the industry is memorialized in the Crouse-Tremaine Works of National Carbon Co., Fostoria, Ohio. The Bolton Carbon Co. had been formed to help satisfy the demands for lighting carbons, and W. H. Lawrence, who was associated with the Brush Electric Co., bought an interest in Bolton in 1886. While contributing immensely to the science and practice of carbon technology, these men at the same time found their mutual efforts and interests so similar that a business association was formed that emerged in 1886 as National Carbon Co. Inc., in Cleveland, with Lawrence as its first president.

While the manufacture of arc carbons, battery plates and electrodes was adding important

The Largest Shipment of Furnace Electrodes Ever Made, More Than 1,000,000 Lb., Was Carried by Barge From Columbia, Tenn., to Chicago

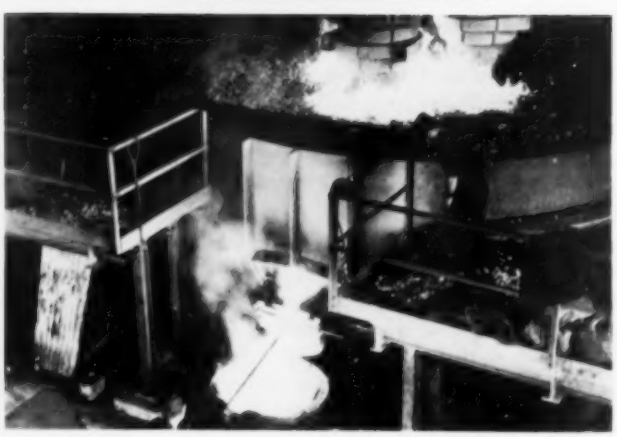
knowledge to carbon chemistry and improved methods of manufacture, the development of the electric furnace gained headway as soon as the power problem was solved. Twelve years after the first dynamo was built, Siemens patented both his horizontal and vertical types of electric-arc furnace and, in 1880, Heroult produced the first of the many types of electric furnaces to bear his name. In the same year Hall invented his process for producing aluminum, antedating Heroult slightly.

One of Acheson's most outstanding accomplishments was the development of an electric resistance furnace in which materials could be processed for making the new abrasive, Carborundum, which he had synthesized in 1891. He also was thinking in terms of manufactured graphite, and in 1897 built the first graphitizing furnace in the world.

The opportunity to begin graphitizing operations was provided by H. Y. Castner, who approached Acheson to graphitize carbon anodes purchased from the Washington Carbon Co. The first load of oval anodes, ¾ × 1¾ × 15 in. in size, was delivered for graphitizing in May 1897. The graphitizing furnace was 16 ft. long between heads. The first charge consisted of 2905 carbons, weighing 2300 lb., which were piled crosswise in order to keep the resistance of the furnace high. The carbons were stacked as solidly as possible, in view of their shape, in a single pile 1 ft. high between the two furnace heads, and a 2-in. layer of powdered coke was placed around the

Electric Resistance Furnace for Graphitizing Electrodes

Electrodes Ready for Shipment From National Carbon Co. plant



Tapping a Ferrosilicon Submerged-Arc Electric Furnace. (Courtesy Pittsburgh Lectromelt Furnace Corp.)

pile to prevent contact between the carbon and the Carborundum mixture which surrounded the whole load. Power was applied on June 7, 1897, and the run continued at 7800 amp. The end of the run was determined by guesswork. Before the end of that year, 142,500 lb. of electrodes had been graphitized.

Dr. Acheson had secured many patents on his "purified carbon" (manufactured graphite) between 1895 and 1899, and about 1900 started the manufacture of joinable electrodes. Prior to that date the working cycle of the electric-arc furnace was short, erratic and not too satisfactory because the electrodes could not be joined to produce a continuous column; this would be considered an impossible limitation today. In addition, Acheson was very concerned about the stub loss in electrode use because they were nonjoinable. Several methods of joining were tried, such as dowelling and dovetailing, but none was satisfactory. A natural sequence was threading the ends so that one end of the electrode carried a male thread and the other a female thread. The threads on carbon electrodes were molded because of the difficulties of machining, but the softer graphite could be machined.

Shortly after the turn of the century Acheson again improved the method of joining by the use of threaded sockets and a separate threaded connecting pin. The only modification since that development was the tapered electrode joint, introduced some years ago, which has become the standard in the United States for practically all graphite electrodes used in open-arc furnaces.

World War I propelled a rapid expansion of the electric furnace industry and the electrode manufacturers kept pace. During the war years National Carbon and Acheson Graphite worked together in producing graphite electrodes up to 14 in. diameter. Although the quality at that time was considered satisfactory it would hardly satisfy the high standards required today.

National Carbon Co., Inc., became a subsidiary of Union Carbide and Carbon Corp. in 1917, and the Acheson Graphite interests were acquired by the Corporation in 1928.

The demand for larger and larger electrodes, which began practically at the moment the first electric-arc furnace was put in operation, always has been satisfied. Thirty-inch diameter carbon electrodes were first made in 1926, the 35-in. diameter followed in 1927 and the 40-in. diameter in 1930. Currently they are being made in 45-in. diameter, with much larger diameters in the planning stage.

The war experience of 1914 to 1918 in making 12-in. and 14-in. graphite electrodes was used to advantage when the demands of the industry made it necessary to produce a 16-in. diameter. The 18-in. diameter was first made in 1930, but it was not until 1937 that the 20-in. was needed. Graphite electrodes are at present being made up to 45 in. diameter and 110 in. long.

The submerged-arc furnace, in reality, cradled much of the early arc-furnace development, and at the same time it was the laboratory for electrode research before the electric steel furnace came into its own. The submerged-arc furnace, used in the production of so many different materials, imposes special conditions that are not found in the steel furnace. Millions of pounds of electrodes are used each year in submerged-arc furnaces. Generally these are large-diameter coal-carbon electrodes.

Here again, we must look backward in order to keep the perspective in full focus. Major James

Ring-Type Gas Baking Furnace for Large Electrodes

Turner Morehead and Thomas L. Willson organized the Willson Aluminum Co. and built a small plant near Morehead's idle cotton mill at Spray, N.C. There in 1892, after many failures to make aluminum from its oxide in the intense heat of the new electric furnace, a grayish, crystalline substance emerged and the furnaceman attempted to quench it with water. Volumes of gas rewarded his efforts, for the gray material was calcium carbide and the gas was acetylene. Today, the submerged-arc furnace smelting of calcium carbide for acetylene production is a major industry, responsible for most of the acetylene gas used in welding, cutting and surfacing, in the synthesis of vinyl and rubber plastics and acetic acid. Its possible future uses challenge the imagination.

Elemental phosphorus is produced in the submerged-arc furnace; it never is found by itself in nature. Two generations ago, the entire world's production of elemental phosphorus did not exceed 400 tons. Today, this country uses ten times that amount for safety matches alone—a dim flicker in the light of an industry which is continually expanding to meet the development of new processes and applications.

Unlike some earlier, easier victories over alternate methods of manufacture, the electric-arc furnace competed vigorously with the blast furnace production of phosphorus for 27 years (1910 to 1937) before establishing the clear-cut advantage it holds today in this field. Used in vast quantities for foods, medicines, detergents and fertilizers, electric-furnace phosphorus has come a long way from the days of the "strike-anywhere" match, and more new uses are in view.

Since the early 1900's one of the largest single users of coal-carbon electrodes has been the ferro-alloy industry. Such alloys are best made in submerged-arc electric furnaces because they usually are found in nature as oxides and the better grades must be reduced at the extremely high temperatures economically attained only in the electric-arc furnace. Large coal-carbon electrodes are generally used. The temperature inside an electric ferro-alloy furnace is tremendous – a miniature hell inside a steel shell. In the larger furnaces there may be more than 25 sq.ft. of electrode surface delivering power at arc temperatures of 6700° F.

The physical and mechanical properties of various types of carbon vary over an amazingly broad range. For example, the electrical conductivity of different carbon products differs by a factor of 100, mechanical strength by a factor of 7, and heat conductivity by a factor of 30. These wide variations had been the despair of every investigator who worked in this field, yet it is quite probable that they explain why carbon has been so versatile. In graphite electrodes high electrical and heat conductivities and low thermal expansion are necessary in order that they may withstand the thermal stresses set up by a 45,000-amp. arc at the electrode tip.

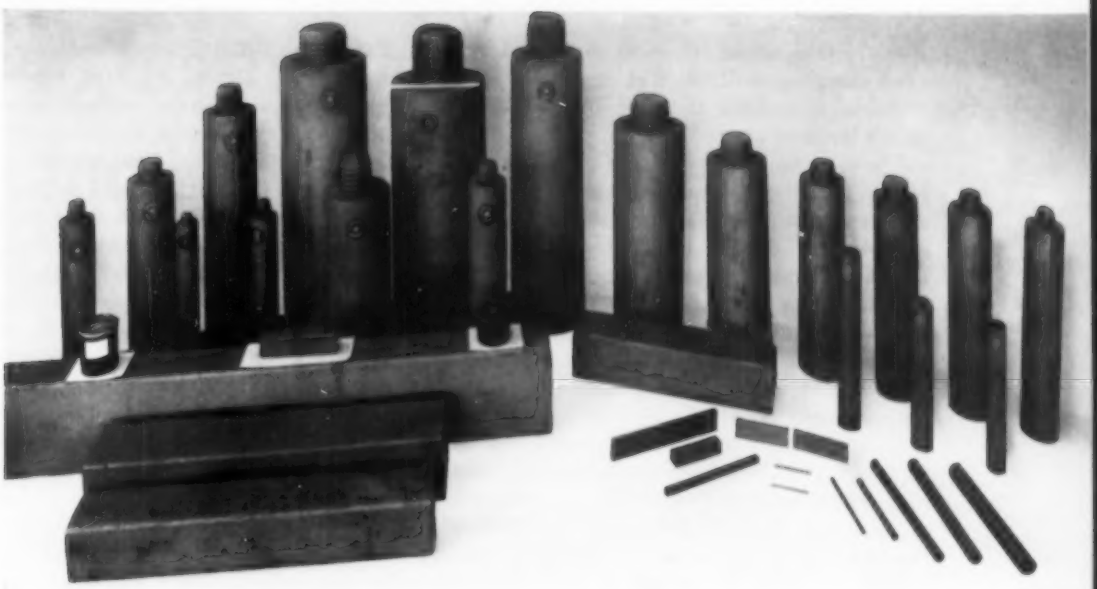
Four main factors determine the final properties of every carbon product: (*a*) the kind of carbon base material, (*b*) the amount and kind of binder, (*c*) the compacting pressure, and (*d*) the firing temperature. Of these four, the most important are the kind of carbon base material and the final firing temperature.

Petroleum coke, a byproduct in the distillation of petroleum during gasoline manufacture, is the primary ingredient of articles to be graphitized. Coal (anthracite and metallurgical coke) is the primary ingredient for carbon products. Coal tar pitch, obtained from the distillation of coke-oven tar, acts as a bond to hold together either the coke or coal particles.

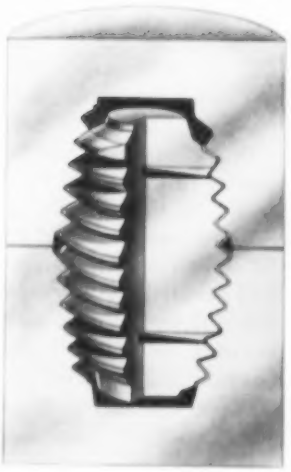
In general, all carbon products are formed by incorporating a binder with some kind of carbon aggregate to form a plastic mass which can either be extruded or molded. It is then fired at a high temperature to coke the binder and render the mass infusible. The binder must be a substance which is capable of leaving a carbon residue when decomposed by heat. The amount of this residue, called bond carbon, determines to a great extent the properties of the product. For example, a sugar solution might be used as a binder (as, indeed it was in earlier days); however, it would be ineffective since the carbon residue of decomposed sugar amounts to only 10% of the weight of the sugar.

Three types of heat treatment are basic in every electrode plant. Calcining, the first of these, preshrinks the carbon materials before they are bonded together. This is necessary because most carbon materials undergo volume shrinkage of the order of 25 to 35% when heated to a temperature of 2550° F.

The second heat treatment is known as gas baking. In this operation the binder is decomposed by heat, leaving a carbon residue which acts as a bond to hold the particles together. The final temperatures of this heat treatment in the electrode plants range from about 1470 to 1830° F. Slightly more than half of all carbon made is finished at these temperatures. At this stage there is considerable similarity between all types of carbon, irrespective of the raw materials employed.



Typical Carbon and Graphite Electrodes



New Connecting Pin Contains a Reservoir Filled With Pitch Which Flows Out in Service and Locks the Joint

The third treatment, for which Dr. Acheson coined the term "graphitization", takes the previously fired products to temperatures in excess of 4700° F. It is this heat treatment which develops to the highest degree the desirable properties of carbon for open-arc furnaces. Electrical conductivity of a petroleum coke product is increased fivefold and thermal conductivity is increased twentyfold. Before graphitization, the carbon will take the edge off any cutting tool; after graphitization, it can be machined with ease with ordinary toolsteels.

The contrast in the behavior of carbon products made from different materials is of basic importance to a full understanding of carbon. This was only one of the early steps in the constantly increasing tempo of research findings which were initiated by National Carbon Co. when it established, in 1902, the first industrial research laboratory in the nation. A new "research laboratories center" is opening this spring. The new laboratories will engage in basic, exploratory work on solid-state physics in the broad, abstract sense as well as the practical investigation and design of materials to meet future requirements of industry. These studies will broaden the existing facilities which cover fundamental physical and physiochemical studies of carbon and graphite electrodes, their raw materials and their possible modifications.

Fifty-five years of research study have now been devoted to the composition, construction, characteristics, production and behavior of carbon in its many physical forms, under all sorts of conditions. The requirements of graphite as the "moderator" in the enormous piles for producing plutonium for the atomic energy process re-emphasized the importance of its nuclear structure and properties, as well as its crystalline structure and chemical and physical characteristics. The basic nature of these determinations required use of X-ray and electron diffraction and other highly

specialized instruments and techniques of a classified character – all aimed at increasing the fundamental knowledge of the element carbon and its applications.

The most important aspect of electrode manufacture is quality control, which requires constant and minute inspection at every step in raw material selection and preparation, through each manufacturing operation so that each electrode has built-in characteristics that are uniform year in and year out. Control for short periods is easy; control of quality from one year to the next is most difficult of attainment and requires many years of experience.

To assure high and uniform quality, National Carbon Co. "makes" many of its own raw materials. The components of modern electrodes are as many and varied as a contrary mother nature can make them. Before use the ingredients must be converted to a specific high standard of quality by refining and processing. The finished raw materials then are put through a complicated procedure of mixing, blending, calcining, crushing, screening, milling, molding, extruding, baking and graphitizing. Extreme care is exercised throughout to assure a uniform product.

One example of quality control is in the machining of graphite electrodes with tapered joints, where the threaded dimensions must be held to close tolerances so that the assembled joint will be as similar to the electrode body as possible. It is essential that the nipple and sockets be well mated to insure adequate strength and maximum electrical conductivity. Some years ago studies disclosed that tapered graphite connecting pins or nipples smaller in diameter and shorter than those previously used would make better electrode joints with higher electrical conductivity and better strength. Furthermore, the small joints are less expensive and are conducive to lower production costs per ton of steel. Conversion to the smaller type of connecting pin is now going forward rapidly.

A more recent development is National Carbon Co.'s new pitch-reservoir connecting pin (U.S. Patent No. 2735705) which keeps electrode joints tight. Identical with standard, tapered graphite nipples in size, shape, tolerances, composition and quality, this new nipple design is distinguished by the pitch-filled reservoirs near each end of the threaded portion. As the connecting pin becomes hot, the pitch flows from the reservoir into the threaded section of the joint where it cokes out, cementing and locking the threads of the nipple and socket together. This action occurs at temperatures well within the range of the operating column. No application of cement or dowels is required. This type of connecting pin is highly effective in eliminating collar and nipple loss at the arc end of the electrode, and increases furnace efficiency.

The electric-arc furnace for steel has now been with us for 50 years. During the early years progress was slow because a deep and firm foundation of proven performance was being built. In more recent years progress has been rapid and for some time now the electric-furnace steel industry has been enjoying a state of dynamic growth. Who can say what lies ahead? Will it be a further expansion into carbon steel production? Will it be a growth in the size of the furnace, with larger and larger electrodes? Will the future furnace have 6, 9 or 12 electrodes; multiple phase, ultra-high-frequency power supply; a fixed mast and roof with interchangeable shells? Will it be hermetically sealed with controlled atmospheres and charged, regulated and controlled by a punched-card system? Or will the entire concept of electrothermal science undergo radical changes?

Such things are conjectures, but we know that on the 50th anniversary of the first U.S. electric arc furnace for steelmaking, the continued exploitation of the inherent advantages of the electric-arc furnace and continued development and improvement of its design will further promote the phenomenal expansion of its applications. We know also that whatever the future demands are, the electrode manufacturer will be ready, as in the past, to provide exactly the proper electrode to do the job at hand.

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New Thermocouple for Service in Reducing Atmospheres

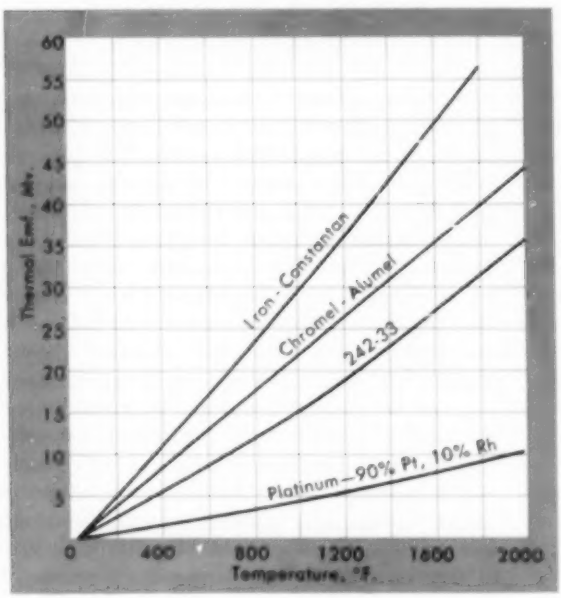
*By CHARLES L. GUETTEL**

Two new thermocouple alloys are more resistant to the corrosive attack of reducing gas and retain thermal emf. stability longer than conventional base-metal thermocouples. (S 16, SG-a)

When exposed to reducing atmospheres at elevated temperatures, most thermocouple materials deteriorate from the corrosive attack of the gases. As they deteriorate the thermal emf. generated at a specific temperature decreases and indicates a lower instrument reading. If such a couple is used for control, the furnace will overheat and may even burn out.

Because reducing atmospheres have become very popular in heat treating, most furnace operators carefully check protection tubes to prevent exposure to the furnace gases, and require that the control thermocouple be calibrated frequently and regularly. Unfortunately, protection tubes can fail and at high temperatures, deterioration can be so rapid that a charge may be overheated and ruined between calibrations.

Relation of Thermal Emf. and Temperature



At Driver-Harris Co. a number of combinations of alloys have been investigated to find a pair that would not only be stable in reducing atmospheres, but would also have sufficient thermal emf. sensitivity for the close temperature control now required in heat treating. The thermocouple† that has been developed satisfies both these requirements. In addition, if after prolonged exposure to attack, it should drift off calibration, the thermal emf. generated would increase slightly and would cause only a small drop in the temperature of the furnace.

The nominal compositions of the new alloys, designated No. 242 and 33 are:

	Positive Leg (242)	Negative Leg (33)
C	0.10%	0.05%
Si	1.00	3.0
Cr	20.00	—
Cb	1.00	—
Ni	Bal.	Bal.

*Manager of Laboratories, Driver-Harris Co., Harrison, N.J.

†U.S. Patent 2,691,690, Oct. 12, 1954.

Although the thermal emf. response is somewhat lower than that of other base-metal thermocouples, its sensitivity (mv. per degree) is equivalent in the higher temperature range for which it is designed. A comparison of the relation of emf. and temperature for the 242-33 thermocouple and other commercial thermocouple combinations is shown in the graph.

To determine the relative stability of the alloys when used in a reducing atmosphere, representative thermocouples of the new type were exposed in a furnace at 1750° F. adjacent to a conventional base-metal couple.

A flowing gas atmosphere was passed continuously over the bare thermocouples. Nominal composition of the gas was 16% H_2, 10% CO, 5% CO_2, 1% CH_4 and the balance nitrogen. A temperature of 1750° F. was chosen to simulate a condition which is known to accelerate green rot attack on nickel-chromium alloys in a reducing atmosphere. After approximately 200 hr. exposure, the drift in emf. of the 242-33 thermocouples was in a positive direction amounting to only 0.01 to 0.13 mv. The drift of the comparison couple was negative and ranged from 7.54 to 7.92 mv. for the same conditions.

Most thermocouples are stable in clean oxidizing atmospheres and can be used for long periods with little deterioration. One major change in the new thermocouple is the increased chromium content (20% compared to 10% in the conventional base metal) which also provides greater resistance to oxidation and longer life in oxidizing atmospheres.

Book Review . . .

Metallurgical Laboratory Manual

Reviewed by F. J. SHORTSLEEVE•

PROCEDURES IN EXPERIMENTAL METALLURGY, by A. U. Seybolt and J. E. Burke, John Wiley & Sons, Inc., New York, 340 p., 1953. $7.00

ALTHOUGH the value of experimental results obtained in metallurgical research depends to a great extent upon the quality of the metal or alloy specimens employed, no single text or laboratory manual has been available which deals solely with the equipment and experimental techniques used to prepare laboratory samples of the requisite quality. It has usually been necessary for the research metallurgist to develop laboratory techniques for melting, working and heat treating metal samples using information that is scattered rather widely throughout the technical literature.

In "Procedures in Experimental Metallurgy", Seybolt and Burke have provided the metallurgical technician with a very clear and concise description of the laboratory procedures and equipment now used in metals research laboratories for the preparation of metal samples, extending from the selection of the raw materials to the final heat treatment of the fabricated products. Without going into complicated detail, the authors describe laboratory methods of obtaining, measuring and controlling desired temperatures; the elements of vacuum systems and the use of controlled atmospheres; and laboratory equipment and techniques used for melting, heat treating and fabricating metal samples. Additional discussion is devoted to the techniques of powder metallurgy; the methods used in preparing high-purity metals such as thermal decomposition of metal halides and electrodeposition; and the methods of preparing metal single crystals.

Numerous simplified diagrams are presented

•Metals Research Laboratory, Electro Metallurgical Co., Niagara Falls, N.Y.

The Electron Microscope Is Standard Equipment in Many Laboratories. (Courtesy RCA Victor)

throughout the book to illustrate the basic concepts of the techniques under consideration, such as the elements of induction heating, thermocouple circuits, potentiometric and millivoltmeter type temperature controllers and the salient features of on-off, two-position and anticipating devices for automatic temperature control.

Considering the current interest of the metallurgical world in reactive metals and the increased emphasis on vacuum melting, the chapter dealing with the technology of vacuum systems should find a great deal of application. The elements of a vacuum system are discussed at length including vacuum pumps, measuring devices, valves and seals, and examples are given of the procedure employed for computing and designing vacuum systems. The metallurgist who has spent many trying hours attempting to locate leaks in vacuum systems will immediately recognize the value of the helpful hints that are given on leak hunting.

An example of the simplicity of the book is found in the section dealing with the rolling of metal sheet. With no reference to plasticity theory, it is pointed out that the maximum obtainable reduction per pass is related to diameter of the work rolls, power available, the lubrication employed and method of feeding the stock. An approximate formula is presented which relates the work expended during rolling to the volume of the metal deformed, the average yield strength of the metal, and the original and final thickness of the metal strip. As a rule of thumb, a ratio of 500 to 1 is given as an approximate value relating the diameter of the work roll to the minimum obtainable thickness of sheet.

A number of very useful tables are included which should save the research technician many hours of searching through handbooks and industrial catalogs. For example, a 14-page table is presented indicating the commercial availability of pure metals for laboratory use. It includes the form in which the metals are available, the purity and, where possible, the principal impurities. The commercial suppliers of metal powders are also tabulated and the available mesh size and purity are indicated. Other tables list the maximum useful temperature of various thermocouple materials and furnace heating elements; suggested temperature ranges for hot working various metals and alloys; the commercial source, properties and principal laboratory applications of a variety of refractories; and the purity and commercial source of available gases.

The authors have, in a very light and readable manner, provided the metallurgical technician with basic instructions in the selection and operation of laboratory equipment. The book is particularly timely because of the current trend for nonmetallurgical students, such as physicists and physical chemists who are not familiar with the techniques of metallurgical research, to apply their talents to metallurgy. Furthermore, it is becoming increasingly advantageous to adapt personnel with limited technical training to metallurgical research. In the areas where this is required, the book by Seybolt and Burke may well become an essential part of the technician's training and will, most likely, become a broadly accepted laboratory manual.

Radioactive Strontium From H-Bombs*

At the outset and on the basis of extensive worldwide research, it is possible to say unequivocably that the nuclear weapons tests as carried out at the present time do not constitute a health hazard to the human population in so far as radiostrontium is concerned—and it is believed with good reason that it is likely to be the most important of the radioactivities produced. Since radiostrontium Sr^{90} is assimilated in the bones it constitutes essentially no genetic hazard, because its radiations do not reach the reproductive organs.

[Radioactive fallout depends not only on the type of bomb but also on the position of the explosion, whether it is in the air, on a ground surface, or under the sea. Most of the fallout from surface bursts occurs within a few thousand square miles close to the site.] The principal radioactivities from nuclear weapons are produced within themselves, and not in the air or other environment.

All nuclear weapons produce atomic clouds which rise to heights dependent upon the energy released, and the clouds from the megaton or high-yield class of weapons rise rapidly to the stratosphere — a part essentially isolated from the troposphere, the lower layer in which we live and where all of our normal winds and storms occur. The smaller kiloton or low-yield weapons produce clouds which stop near the tropopause—the imaginary boundary between the stratosphere and troposphere.

In the troposphere, where rain occurs, any particulate matter will be washed down in a few days or weeks. For example, 0.10 in. of ordinary rainfall will wash the air clean. Even though some radioactive particles may make two or three trips around the earth in a given latitude before being washed out, their lifetime in the atmosphere will be short.

This is in very sharp contrast to the material placed in the stratosphere by megaton weapons. This appears to stay there for an average of 10 years. When the fallout does finally find its way down into the troposphere where the rain and snow wash it out, the precipitation is relatively uniform over the entire globe.

The most important of this fallout (roughly half of that reaching and lingering in the stratosphere) is Sr^{90} — for many reasons: First, it is chemically similar to calcium, and bone is principally calcium phosphate. Sr^{90} will follow calcium into the body. Second, Sr^{90} has a long lifetime — 28 years half-life, 40 years average — and thus a persistent effect. Third, because of its bone-seeking property it stays in the body a long time (and its radiation, if above a safe level, causes an observable increase of bone tumors). Fourth, probability of ingestion through food like milk and cheese can be high. Fifth, about 4 or 5% of all fissioning atoms yield this isotope.

The average square foot of the earth has about 20 g. of calcium available for plant metabolism in the top 2.5 in. This top soil should not contain more radiostrontium than would correspond to ten times the permissible concentration in the human body. To reach this level 11,000 megatons of fission energy would actually have to be released, although ten times this much (as I will indicate later) would be necessary before a man in such an environment would accumulate a maximum concentration where statistically observable evidence of bone tumor should appear. These figures are very far in excess of the total energy released to date.

[What happens to the Sr^{90} reaching the stratosphere?] A slow leakage through the tropopause into the troposphere occurs at the rate of about 10% per year. Measurements on a worldwide basis all show that Sr^{90} fallout carried down by rain occurs all over the world at similar rates, approximately 1.5 millicuries per square mile per year. This very slow process is fortunate. Sr^{90} coming down in raindrops or in the fine morning mists is left behind on the foliage and the soil. (Run-off to rivers and lakes is nearly pure.) That fraction of it which falls on plant leaves has a good chance of being absorbed directly into the plant. Thus, the Sr^{90} in alfalfa and other crops is appreciably higher than the soil on which they grew.

Some of this Sr^{90} absorbed by forage crops carries through to milk. The calcium in milk and cheese is roughly one-fifth to one-tenth as radioactive with radiostrontium as the grass the animals eat. Furthermore, the calcium taken up from the soil into the plant has only half the Sr^{90} that the calcium in the soil has. These two results protect humans, since milk and cheese are the principal sources of calcium in their diet. The Sr^{90} content of human bodies is, therefore, the lowest of all animals and is lower than the average soil and foliage by tenfold.

World-wide evidence about fallout and recent studies of the maximum permissible concentration of Sr^{90} in humans, indicates that the hazard from the present rate of testing nuclear weapons is insignificant. A total of 11,000 megatons of TNT equivalent of fission would just yield a Sr^{90} content in humans equal to the maximum permissible concentration (1 M.P.C., the amount considered safe). At less than 10 M.P.C., or below 110,000 megatons energy equivalent of fission, statistically observable incidence of bone tumor should not appear. At 30 to 40 M.P.C., or 330,000 to 440,000 megatons, the likelihood of untoward effects would be appreciable. Even the lowest figure—11,000 megatons—is very far in excess of the total energy released to date.

*Verbatim extracts from address on "The Radioactive Fallout and Radioactive Strontium" by A.E.C. Commissioner Willard F. Libby at Northwestern University, Jan. 19, 1956. See also extracts from another of Dr. Libby's addresses printed in *Metal Progress*, Oct. 1955, p. 130, on the genetic effects of atom bombs. Matter in brackets represents the Editor's phraseology.

Chromate Conversion Coatings for Copper Alloys

*By R. STRICKLEN and E. L. GABEL**

A new series of balanced chromate solutions will produce a protective mirror-bright finish on copper and most of its alloys. Chromium can be plated directly to these coatings without an intermediate layer of nickel. (L 14, Cu)

COPPER alloys tarnish slowly in air and since they are often used for decorative applications, the problem of obtaining a bright finish and maintaining it during stockroom or shelf life and in service is of major concern to many manufacturers. Buffing, or some other mechanical polishing method, is often used to obtain the necessary brightness but is relatively expensive and sometimes impossible for complex parts.

Much more widely used for brightening copper alloys is the sulphuric-nitric acid dip. The composition of the solution varies from plant to plant but a typical bath contains 60% concentrated sulphuric acid, 25% concentrated nitric acid and 0.2% concentrated hydrochloric acid. After dipping, the parts are rinsed in cold water, then rinsed in a sodium cyanide solution to remove any acid stains, rinsed again in water and dried. The acid must be removed completely before immersion in the cyanide; otherwise, deadly hydrocyanic gas may form.

The disadvantages of this type of bath other than the possible evolution of corrosive and poisonous fumes are that it has a relatively short life and often requires cooling because of the heat of reaction. The metal so treated is not always uniformly bright and the surface is quite active and tarnishes readily after rinsing.

A patented chemical polishing bath which gives more uniform results contains nitric, acetic and phosphoric acids. However, it does have some of the same disadvantages — evolution of poisonous and corrosive fumes, short bath life and a reactive surface on the brightened copper.

Chromic acid or dichromate baths have also been used in pickling copper alloys and have overcome some of these difficulties. Fumes are eliminated and operating temperatures are not as critical. However, the surface obtained is usually crystalline and semibright, rather than mirror-bright.

Recently, Allied Research Products, Inc, developed a new series of chromate mixtures whose compositions are balanced so that they provide more uniform results and longer bath life and eliminate the need for separate control of individual constituents. One of these, called Iridite No. 7, is a solution in which copper and most of its alloys can be chemically polished to mirror brightness and the surface will resist tarnishing. Another advantage is that chromium may be plated directly on the brightened surface without an intermediate nickel plate.

The protective value of the coating will vary with the type of treatment, its thickness and with the alloy to which it is applied. For example, in salt spray exposure of brass parts, the corrosion resistance increases with the zinc content of the alloy. In one instance, brass wave guides in electric equipment at a waterfront location showed no tarnishing after more than six months'

*Allied Research Products, Inc., Baltimore, Md.

Conversion Coating on Copper-Plated Lampshade and Electrical Connectors Increases Corrosion Resistance and Prolongs Shelf Life

exposure. The mechanism of protection is believed to be the same as for other metals on which chromate conversion coatings are applied, namely, a gel-like nonporous film which retains soluble hexavalent chromium as an inhibitor.

The coatings generally exhibit low electrical resistance. Where contact resistance or solderability is critical, a compromise on the degree of protection may be necessary and thin films should be used. Preliminary tests indicate that the spot welding characteristics of brass-plated steel are improved by the use of thin films.

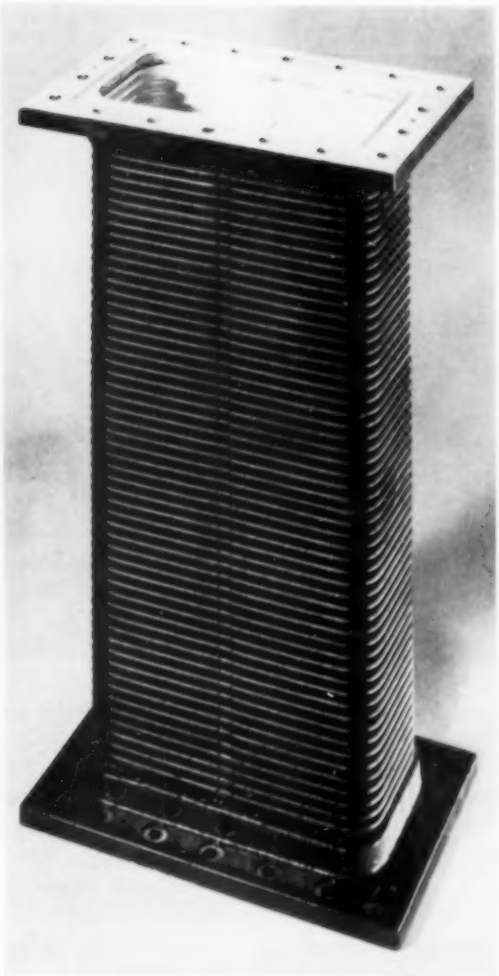
Chemical polishing is limited to selective etching of metal from the high spots and some metal must be removed to obtain a bright finish. Iridite No. 7 removes metal at a rate of 0.0002 to 0.0003 in. per min. The smoother the surface is at the start, the shorter the immersion time required. Consequently, if copper or brass-plated parts are to be brightened, the plate must be fine grained and semibright so that a few seconds' immersion will complete the brightening. If the plate is dull, it must be thick enough to stand chemical polishing for a minute or more. It has been found uneconomical to try to polish burned deposits.

In electrolytic polishing, metal is removed uniformly until a layer of solution of high metal concentration is formed at the metal-solution interface. Due to its high specific gravity, this solution runs off the work surface, exposing the high spots to fresh solution. The dense solution tends to remain in the low spots and the slower diffusion here retards the metal solution rate. Chemical polishing is similar. The heavy film formed on the work contains freshly dissolved metal and precipitated trivalent chromium which assists in the formation of the film. The advantage of chemical polishing over electrolytic polishing is that current distribution need not be considered.

Mirror-bright surfaces are obtainable on wrought alloys which are fine grained and homogeneous. If the grains are too coarse, the surface will be bright, but not truly flat and smooth. Heterogeneous alloys such as leaded free-cutting brass, beta brass and phosphor bronze do not dissolve uniformly and consequently are not brightened as well as homogeneous alloys.

Iridite No. 7 is supplied as a stock solution and used full strength. To prepare the working solution, ¾ fluid oz. of 35% hydrochloric acid is added to each gallon of stock solution. Sodium chloride, or other chloride, may be substituted for the hydrochloric acid in chemically equivalent quantities. The operating temperature is 80 to 120° F. Immersion time may vary from a few seconds to 3 or 4 min., depending on the degree of chemical polishing desired. Slow agitation is beneficial. A cold rinse is the next step and vigorous agitation in the rinse is desirable.

If a bright surface with fairly high tarnish resistance is desired, the work may be dried at this point. A visible iridescent chromate film covers the surface. If the natural color of the metal is desired, the work may be bleached in an acid solution consisting of 1 part Iridite No. 7 and 19 parts water. The work is immersed from 5 to 10 sec. at room temperature. For maximum brightness, cold rinsing, hot rinsing and drying complete the operation.



Electronic Wave Guide Coated on Interior for Corrosion Resistance and Exterior as a Paint Base

For work which is to be chromium plated after brightening, a bleach should be used prior to chromium plating if the transfer time exceeds 15 sec. This is usually necessary where automatic equipment is used. The bleach dip should consist of 5 to 10% by volume of hydrochloric or nitric acid.

If plating other than chromium is to be used, the Iridite film should be removed in an alkaline solution. The alkaline solution may be caustic soda at 4 to 8 oz. per gal. or an equivalent alkaline cleaning compound at 160 to 200° F. Immersion time is ½ to 1 min. with soak or cathodic electrolytic cleaning. This is following by a water rinse and a neutralizing dip of sulphuric or hydrochloric acid. Plating racks should be insulated to avoid chromium contamination of the plating solutions.

For decorative applications such as giftware and automobile trim, the chromate solution is used to brighten copper plate prior to direct chromium plating. With most bright copper-plating processes, a mirror-bright deposit can be obtained consistently only under closely controlled operating conditions. Such a deposit is essential if the subsequent chromium plate is to resemble chromium plated over bright nickel.

Bright copper deposited under normal commercial operating conditions is usually hazy or milky in appearance. Color buffing is frequently used and even with the high cost of individual handling of the parts, the finish is not truly mirror-bright. Electrolytic polishing of the copper deposits has been tried. The results are not generally much better than buffing, since the problem of current distribution, throwing power and general process control are multiplied when a wide variety of shapes and sizes must be treated in rapid succession.

Iridite No. 7 produces a uniform chemical polishing action. Thus chromium plate applied directly to copper so treated looks like it was applied over bright nickel plate. It is used not only in direct chromium plating but also when a small amount of nickel is available. Thin nickel plates, while bright in themselves, do not take advantage of the leveling properties of the plate. The conversion coating does aid in leveling and its brightness is equivalent to that of a heavy nickel plate.

Production installations have been operated continuously over a period of more than two years. Most of the operations are hand dipping of racked parts or small lots of bulk parts.

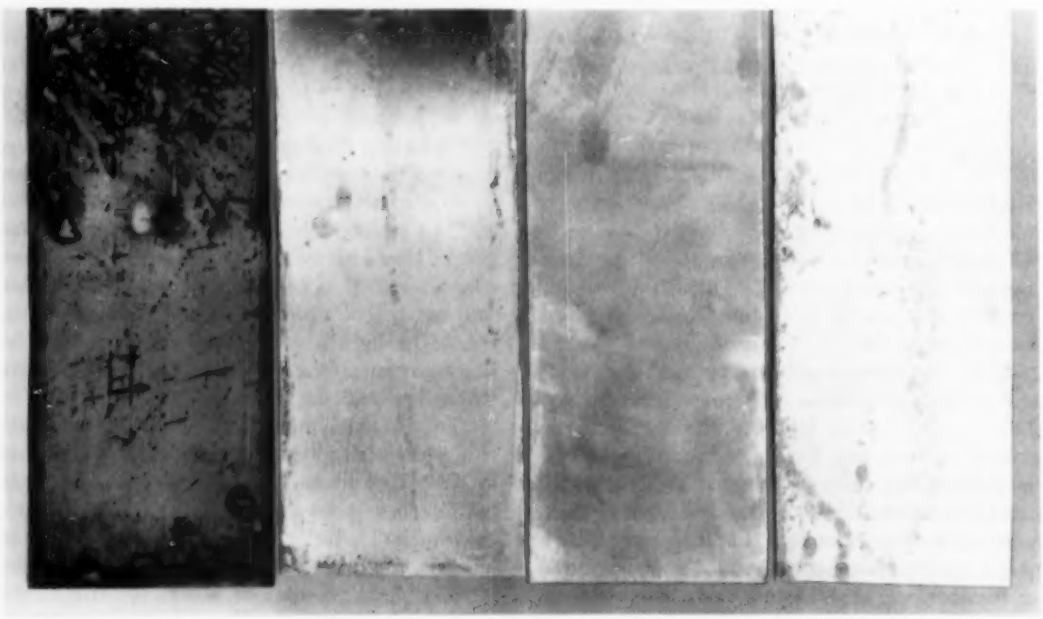
We have a different kind of chromate mixture to use if the copper or brass parts are to be dyed or require better corrosion resistance. It does not brighten the surface but coats it with a film that can be thin and invisible or heavy and iridescent. The heavier films are more resistant to corrosion and may be covered with water-soluble organic dyes. The light film may be used as a base for other organic finishes and for electrical work where low contact resistance is required.

The chromate mixture, which we call Iridite No. 17-P, is supplied as powder. It is dissolved in water and a small amount of either nitric or hydrochloric acid is added. The hydrochloric acid, or "A" solution, doesn't polish the surface but provides a heavy, highly protective film. The nitric acid, or "B" solution, is used to form a light

Results of 24-Hr. Salt Spray Test on Copper. From left, the samples are uncoated, coated with Iridite No. 7, 17-P ("A" Mix) and 17-P ("B" Mix)

clear passive film. Both solutions are operated at 75 to 90° F. and the work is immersed for 5 sec. to 3 min., then rinsed and dried. This process is particularly adapted to leaded brass because a powdery layer of lead chromate forms on the surface in many chromate solutions. This powdery formation does not occur when the heavy protective film is applied.

Brass Panels After 100-Hr. Exposure to Salt Spray. Uncoated, coated with Iridite No. 7, 17-P ("A" Mix) and 17-P ("B" Mix)



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Please contact the nearest ELECTROMET office. Ask for ELECTROMET's new 4-page brochure on electrolytic manganese and the booklets on melting low-carbon stainless steel.

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Correspondence . . .

Counterfeit Detected

DENVER, COLO.

My attention was aroused by the article by E. W. Horvick entitled "Reproducing a Roman Coin" in the December issue of *Metal Progress*, since collecting genuine ancient coins is one of my hobbies. In the interests of accuracy I believe that a few points should be brought to your attention.

The somewhat coarse portrait on the illustrated piece is not that of "Emperor Caesar Nerva" (96 to 98 A.D.) but actually is Emperor Marcus Ulpius Trajanus (98 to 117 A.D.), commonly known as Trajan. A comparison of the coins from my own modest collection will show that the two faces are not difficult to distinguish. Nerva had an elongated type of profile compared to the rounded configuration of Trajan's head, and the former had a rather pronounced nose.

The fact that the name, "Nervae", appears in the inscription can be ascribed to the relationship between the two emperors. Trajan directly succeeded Nerva and was the latter's adopted heir. As was the custom in those days, the heir acquired the name of his foster parent, and in this particular instance the son used the combined name on many of his coins. Since Trajan's name frequently appeared on his coins as "Imp Caes Nervae Traiano Avg", it must be assumed that the sculptor of the model erred in deciphering the inscription, since it appears in the illustration as "Imp Caes Nervae Ifriano". Possibly the inscription on the copied coin was indistinct. Additional evidence from the inscriptions points to Trajan rather than Nerva. The "Dac" and the "Optimo Princ" are characteristic of Trajan and are often seen on his coins. The "Dac" (abbreviation of Dacicus) commemorates his military victories over the Dacians, and "Optimo Princips" is a complementary title which is common only on his coinage.

I thought the article as a whole was quite interesting, because it demonstrates modern technology being applied to an ancient art. It also illustrates some of the difficulties encountered in mass-production counterfeiting, and makes one marvel at the industry of the ancients who produced the originals in large quantities without benefits of modern conveniences.

FRANK C. PERKINS
Research Metallurgist
University of Denver

Coins of Roman Emperors Caesar Nerva (Left) and Trajan (Right). 2½ ×

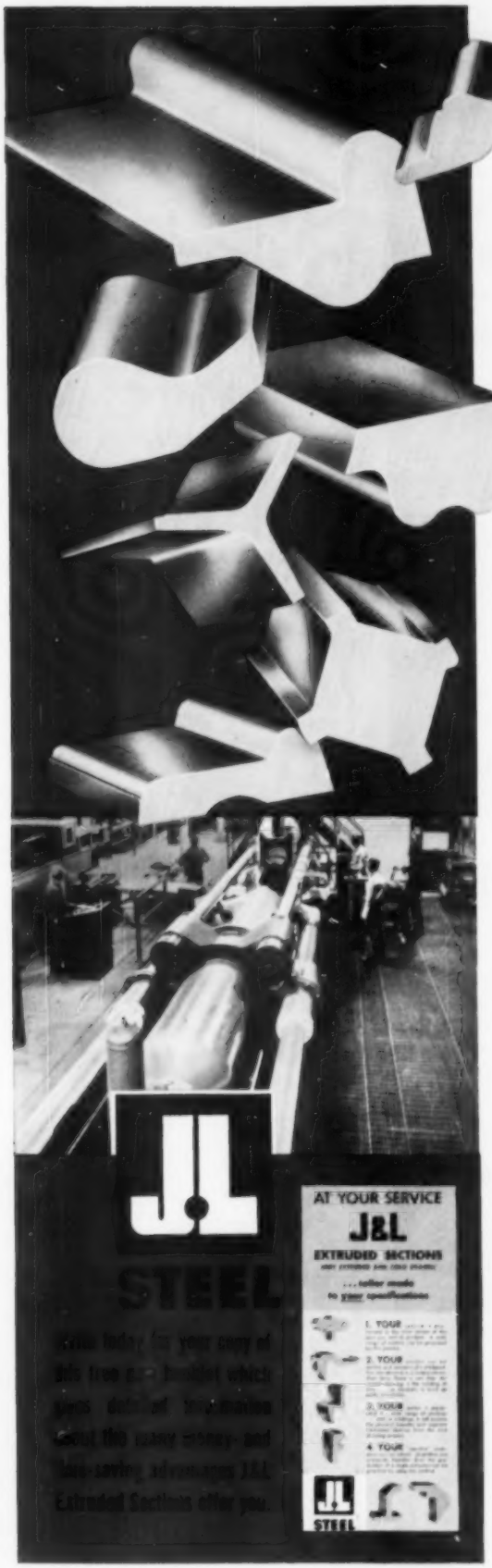
Industrial Planning in U.S.S.R.

PITTSBURGH

A three-man party, consisting of A. C. Hall of Bendix, N. L. Bean of Ford Motor Co., and the undersigned, spent two weeks in December in the U.S.S.R. in a tour directed by the Soviet Government visiting a half-dozen automotive and bearing factories and four research and development institutes. It would appear that centralized scientific organizations play a much greater part in Soviet industry than they do in America.

Thus, the Academy of Sciences in the U.S.S.R. plays an important role in engineering life. There are several dozen research institutes directly under the Academy, and the director of each is nearly always an academician. It's not a bad job, either. An academician gets a salary of 5000 rubles a month just for being an academician – five times the pay of a mechanic – and he is paid, in addition, for any other positions he may hold.

Manufacturing plants, even those as large as the Stalingrad Tractor Plant, have no research and development departments. Such work is done at central research institutes. The "Experimental Scientific Re-



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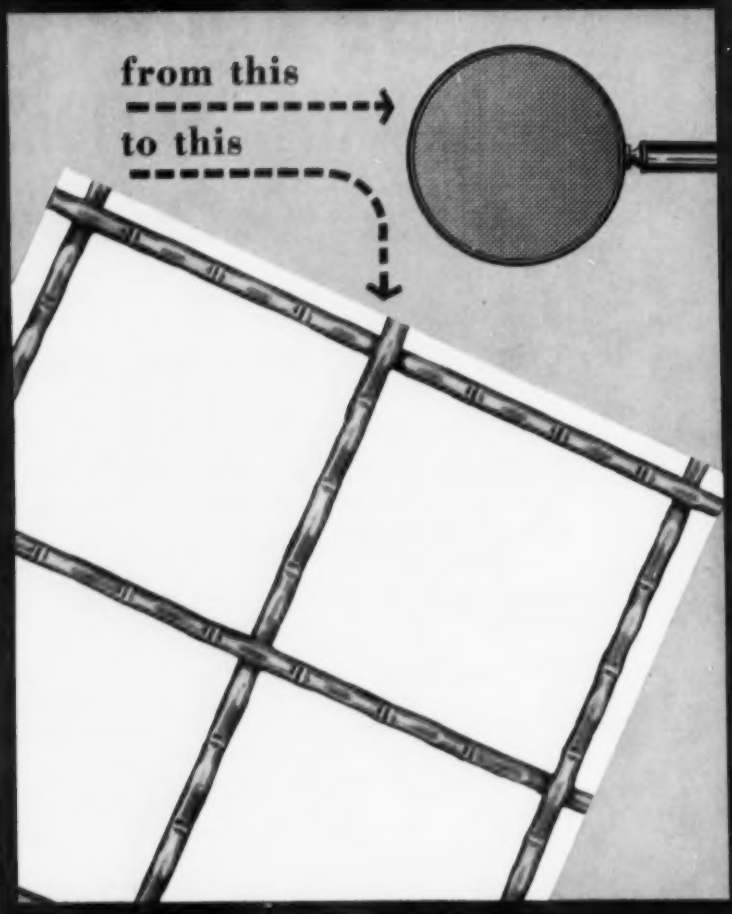

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Industrial Planning . . .

search Institute for Metal-Cutting Machine Tools" or ENIMS is an instance.

This organization works entirely for the machine tool industry. There are 50 different laboratories – each kind of lathe has its own laboratory. There are electric and hydraulic departments which serve in a general consulting relationship to all the others.

The general task of the organization is to improve machine tools and to assist in applying these improvements in the machine tool industry. (It also serves as a general clearing house for technical information.) Machine tools are planned three to five years ahead, working largely from the Institute's own information, plus information from the industries concerned and gleaned from the Russian and foreign technical press.

It is possible for individual machine tool plants to design new equipment, but any design must be approved by ENIMS before production starts. ENIMS considers that its first task is to keep industries from building new units which do not incorporate the latest improvements. In the event of disagreement between ENIMS and the industry involved, the factory is permitted to defend its position and the Ministry of Machine Tool and Instrument Manufacture is the final judge. In general, the factories build and design equipment that is up-to-date now, whereas the Institute plans equipment for the future.

There are also 10 and 15-year plans, but these are of only a very general nature, such as the further use of completely automatic production lines. By an "automatic production line", the Russians mean groups of tools with connections one to the other. An "automatic production line" in this terminology compares quite closely with what we would call a transfer machine.

The ENIMS Institute strives for balanced designs, taking into account speed of the machine, capacity of the machine, automation (including future possibilities), a high use factor, and optimum production of the machine over its lifetime. Machine tools designed here are described in publications of the Institute (of which there are two)

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Industrial Planning . . .

and in various other Russian technical journals.

ENIMS does not hire its staff directly from the colleges, insisting on three years' factory experience before an engineer can be employed in the Institute. There are 450 to 480 engineers who work on fixed wages, plus a bonus, and prizes for outstanding work. Exceptional work may qualify for a Stalin prize. Salaries run from 1400 to 1800 rubles per month. Top salary for an engineer is about 3000 rubles per month, and he may get up to 2000 rubles per month bonus as well. A chief engineer may get 1000 rubles more.

W. H. Brandt
Engineering Manager
Director Systems Dept.
Westinghouse Electric Corp.

Metallurgical Research in India

New York City

I was interested in the article entitled "Metallurgical Research in India" by R. F. Bunshah in the January 1956 issue of *Metal Progress* because three references to "new" developments were made in fields with which the undersigned is well acquainted — at least as to American developments.

The three cases in point are studies at the National Metallurgical Laboratory leading to the production of low-carbon ferrochromium, high-purity manganese dioxide and electrolytic manganese. As far as my reading of the Indian patent and technical literature can discover, all this is a repetition of prior art in the United States. Continuous production of high-purity (99.96%) manganese dioxide on a tonnage scale has existed in the United States for 20 years or more. American plants for electrolytic manganese now have an annual capacity of 15,000 tons, and the metal's capabilities in the manufacture of the 200 series stainless steels and even of plain carbon or low-alloy steel is thoroughly documented.

There is no question that Indian research is developing and the activities of the various Indian research groups in the metallurgical field should be well thought of, cherished,

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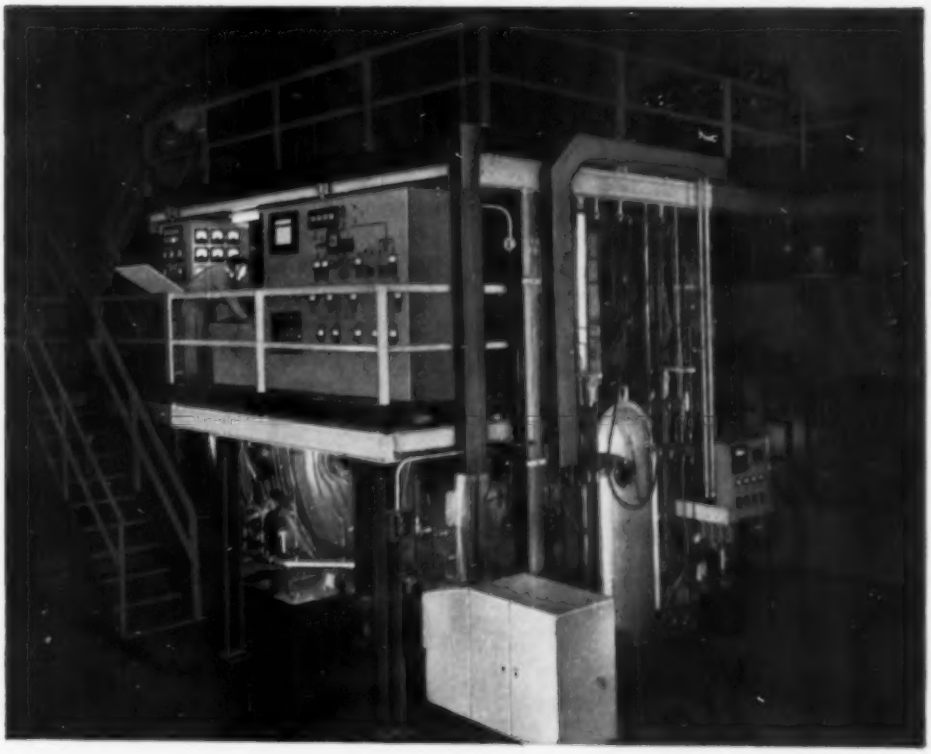

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Research in India . . .

and encouraged. However, it should be unnecessary to describe as "new" a process which (even though it is possible to patent in India processes which have long since been covered by American patents) is well established in the West.

C. L. MANTELL
Consulting Chemical Engineer

Diplomatic Faux Pas

WASHINGTON, D.C.

I noted one item in the January issue of *Metal Progress* which may set U.S.-Swiss relations back a few years. On p. 83 the caption to the photograph states that the reactor constructed by the United States at Geneva was *given* to the Government of Switzerland; it was in fact sold to the Swiss.

E. EPREMIAN
Chief, Metallurgy and
Materials Branch
Division of Research
U.S. Atomic Energy Commission

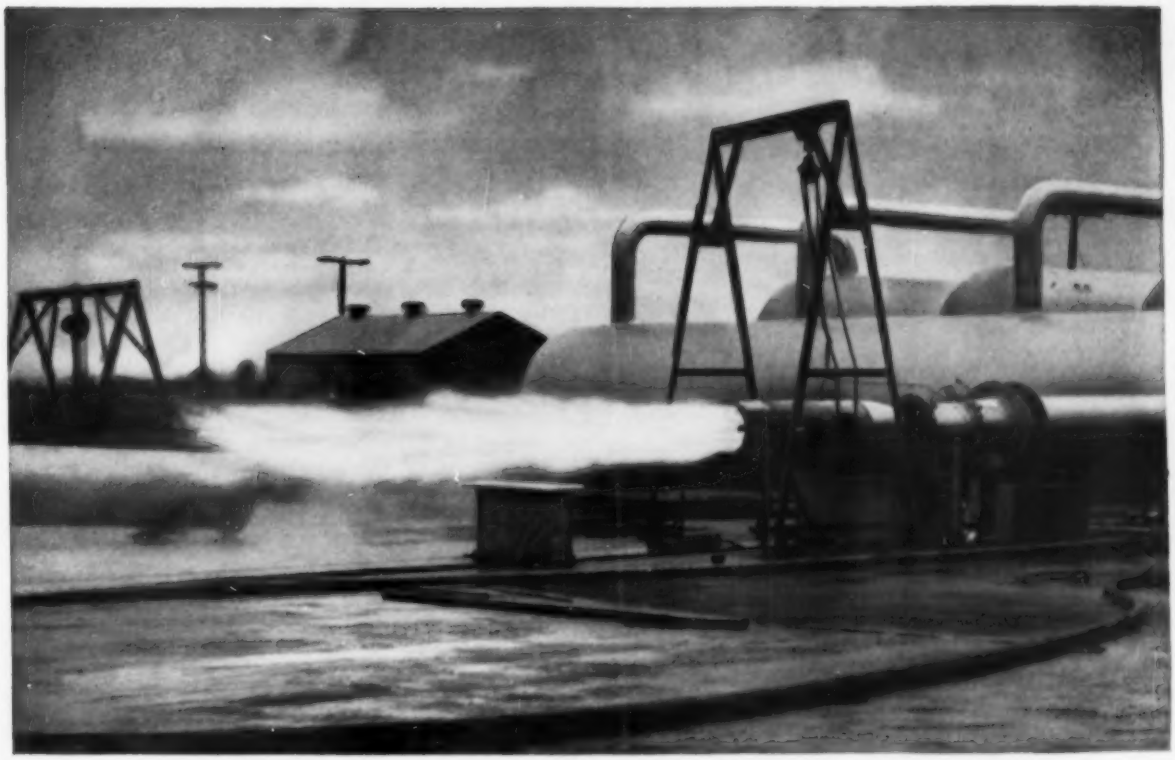
Wanted: A Long-Lived Bearing

RICHLAND, WASH.

We hope some *Metal Progress* readers will be interested in the details of a single problem met in the design of equipment for atomic energy plants, and also have an idea or two – which we would welcome.

The problem has to do with sleeve bearings in totally submerged pumps, stirrers and other rotating equipment. Solutions or slurries are various, but all are corrosive, abrasive and radioactive, and based on chemicals ranging from 50% NaOH to 60% HNO_3, aliphatic or chlorinated hydrocarbons, or ketone-type solvents. No secondary lubricants like oil or grease can be permitted. Loads are less than 50 psi.; temperatures may go up to 220° F.; speeds are from 1725 to 3450 rpm. Shafts may be from 0.75 to 2 in. diameter and ordinarily are of austenitic stainless steel, but non-galling hardened surfaces can be considered.

We are primarily interested in longevity of the equipment, which we believe will depend on the resist-



Ramjet tailpipes withstand severe abuse. (*Photo courtesy Marquardt Aircraft Company*)

MULTIMET Alloy Controls the Blast of Ramjet Engines

Tailpipes used to direct the searing blast of power in today's ramjet engines must withstand temperatures in excess of 2000 deg. F, plus severe vibration. High-speed ramjets operate in the neighborhood of 1500 mph. At these high speeds, vibration is almost as serious a threat to tailpipe life as heat. Because of its strength at high temperatures, MULTIMET alloy has given good service in tailpipes that vibrate as much as three inches.

Ramjet tailpipes are made of MULTIMET alloy sheet that is only 0.051 to 0.078 in. thick. The combined high-temperature strength and oxidation resistance of MULTIMET alloy permits the use of lightweight tailpipes with good heat-transfer properties.

MULTIMET alloy is one of many HAYNES alloys capable of extending the life of parts used at high temperatures. For literature describing the properties of HAYNES high-temperature alloys, get in touch with the nearest Haynes Stellite Company Office.

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E. I. duPont de Nemours
American Brass
Firth Sterling
Raybestos-Manhattan
U.S. Dept. of Agriculture
Colorado School of Mines
General Electric

SPECIFICATIONS

Magnification range: 25-1500X.
Focusing: coarse and fine.
Illuminator: Vertical illuminator with iris diaphragm.
Filters: polaroid, frosted, blue, green, yellow.
Objectives: 5X, 10X, 40X, 100X oil immersion.
Eyepieces: P5X, K10X (micrometer), K15X.

Model MEC is but one of a complete line of metallurgical microscopes by UNITRON—send now for free catalog.

You are invited to try this microscope in your own laboratory for 10 days at absolutely no cost or obligation. Verify its fine optical and mechanical performance. Let this instrument prove its value to you before you decide to purchase.

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MEC MP-APRIL

Bearing . . .

ance of the *bearing* material to corrosion and abrasion. A universally applicable bearing does not seem possible.

Any ideas on the above combination of requirements?

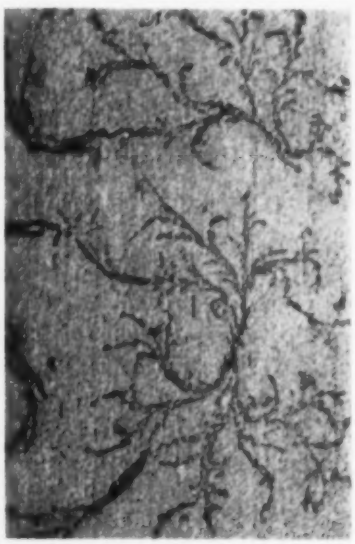
ALVIN E. SMITH
Engineering Dept.
Hanford Atomic Products Operation

Metal Termites

LOS ANGELES, CALIF.

Readers of *Metal Progress* may be interested in seeing the effects of metal termites that we observed the first time we polished or etched AM 350 stainless steel. The magnification is 650 ×, and the etchant used was four parts of concentrated hydrochloric acid and one part of 2% hydrogen peroxide.

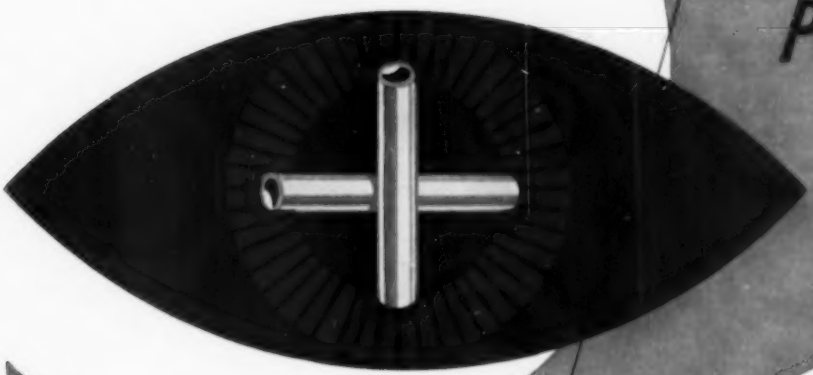
The unusual pattern is not really the work of termites or part of the



structure of this alloy since it did not reappear after repolishing and etching. It was probably caused by etchant seeping from between the metal and mounting material and being blown across the polished surface by compressed air used for drying the specimen.

L. P. SPALDING
Chief Research Engineer
North American Aviation, Inc.

You can see the PLUS VALUES in Ostuco Performance!



1 **You'll see SPECIAL QUALITY Tubing** that lets you turn hidden costs into extra profits. Ostuco's light-weight strength values, more uniform tube walls and fine finish result in seamless and electric resistance welded steel tubing of unmatched quality.

2 **You'll see DESIGN-ENGINEERING SERVICE** go to work on your tubing problems. A wealth of design and production information is at your service. Ostuco's experience dates from the beginning of the seamless tube industry.

3 **You'll see ON-TIME DELIVERY** of tubing as promised! No costly delays that hold up your production. Ostuco has the reputation of making deliveries on schedule.

4 **You'll see "SINGLE-SOURCE" SERVICE** in action and you benefit through convenient, error-free handling of the entire order! Manufacturing and fabrication is under one roof at Ostuco—one order eliminates multiple shipments, saves time and handling costs.

Some good things our customers are saying about OSTUCO:

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Hydraulic Equipment: "We feel partial to you because of the excellent service."

Machine Tools: "You are receiving 100% of the tubing we purchase and will continue to do so as long as you keep up the good quality and service."

Drilling Equipment: "Your tubing is the best we've ever had because of its exceptional straightness and good workmanship."

Blue chip companies, the world over, look to Ostuco for practical solutions to their steel tubing problems. Why don't you ask one of our Tubing Engineers to show you how OSTUCO'S PERFORMANCE PLUS service turns drawing-board ideas into top quality parts faster . . . more dependably . . . with greater savings.

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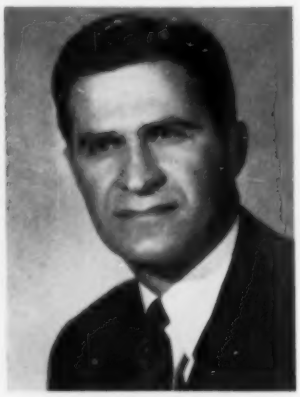
Personal Mention

H. L. Anthony

H. L. Anthony III, administrative fellow at Mellon Institute of Industrial Research, has been appointed director of research, and will guide the Institute's investigational programs in metallurgy.

Dr. Anthony did his undergraduate work at Lafayette College and graduate work at the University of Alabama and Harvard University (M.S. in engineering, 1932; Gordon-McKay Fellow, D. Sc. in metallurgical engineering, 1935). After graduation he was employed by United States Steel Corp. at Homestead as a metallurgical engineer. In 1936 he joined Midvale Steel Co. as assistant director of research and later was made assistant superintendent of foundry. Dr. Anthony joined Mellon Institute in 1939 to head the Fellowship on Metalworking sustained by the Scaife Co. In 1941 he was made senior fellow and nine years later promoted to administrative fellow. Since 1947 he has been a member of the executive committee of the Scaife Co.

In 1947 Dr. Anthony was a recipient of the James F. Lincoln Arc Welding Foundation Award in Research and Education. He was awarded a certificate of appreciation in 1951 by the Department of the Army, in recognition of his research contributions of military value. He is a member of A.W.S., A.S.T.E. and Institute of Metals.



M. G. Fontana

Mars G. Fontana, professor and chairman of the metallurgical engineering department at Ohio State University, Columbus, has received the Frank Newman Speller Award of the National Association of Corrosion Engineers at the Association's national meeting in New York City. The Speller Award is presented in recognition of public contributions made in the field of corrosion engineering.

After graduation from the University of Michigan (1934) Dr. Fontana was a metallurgical engineer and supervisor with E. I. du Pont de Nemours & Co. He joined the staff at Ohio State University in 1945 and three years later was made chairman of the metallurgical engineering department. He is supervisor of metallurgical research for the Ohio State University Research Foundation and director of the corrosion research laboratory in the Engineering Experiment Station. He has served as national president of the N. A. C. E., chairman of the corrosion division of the Electrochemical Society and chairman of the Columbus Chapter of the A.S.M. At present he is preparing the corrosion course for Metals Engineering Institute, a division of the A.S.M.

In 1953 Dr. Fontana received the Distinguished Alumnus Award from the University of Michigan for his achievements.

M. E. Nicholson

Morris E. Nicholson has recently been appointed head of the department of metallurgical engineering at the University of Minnesota. Dr. Nicholson was formerly associated with the Institute for the Study of Metals at the University of Chicago. He graduated from Massachussettes Institute of Technology in 1939 with a Bachelor of Science degree. After an interruption for duty in the Ordnance Department, he returned to school and received his doctorate degree in physical metallurgy in 1947. While in the service at Springfield Armory, he was partly concerned with metallurgical quality of materials in the M-1 rifle. He began his professional career by joining Standard Oil Co. (Indiana) as a metallurgist in the engineering research department, where he worked principally on bearing metals and the formation of sigma phase in stainless steels. For the past few years, he has been interested in the influence of boron on the hardenability of steel and phase equilibria in the iron-carbon-boron system.

Dr. Nicholson is listed in "American Men of Science." He is a major in the Army Research and Development Reserve Program.

J. W. Caum, a member of the American Society for Testing Materials staff since 1946, has been designated senior assistant technical secretary by the Society. Mr. Caum has been working with committees on ferrous and nonferrous metals.

HEAVY EXTRUDED SHAPE

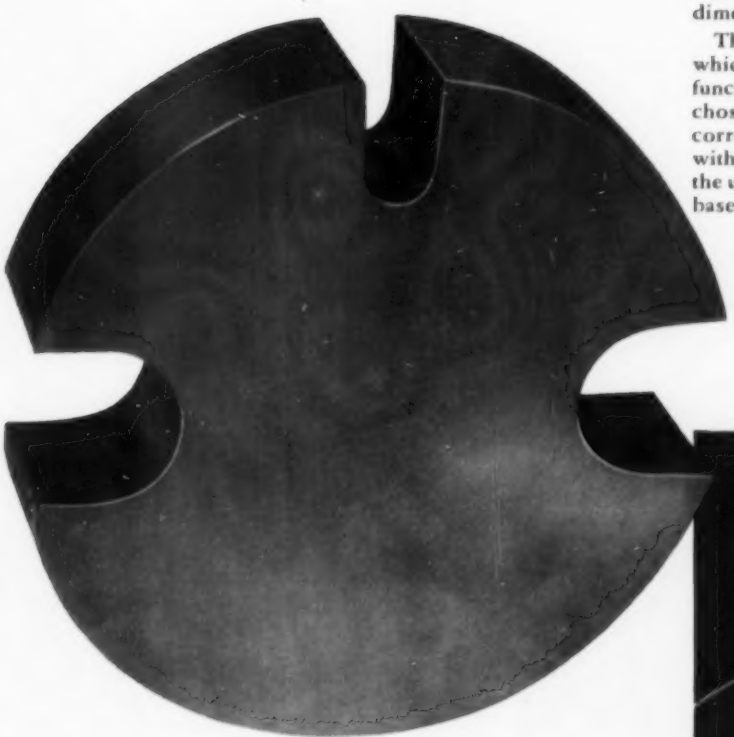
Saves Over 25¢ per lb.

FOR THE STRONG ELECTRIC CORP.

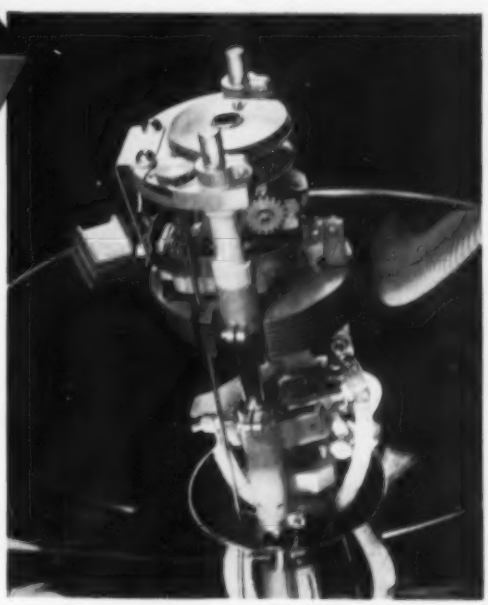
The unusual thing about this copper extruded shape is that it saves money in first cost as well as in machining time. The double economy amounts to over 25¢ per pound. The large illustration shows the shape as supplied in the form of a slug or pre-formed disc, 1 3/16" x 5". This begins as a long extrusion, from which Revere cuts the discs, and pickles them before shipping.

The customer is The Strong Electric Corp., Toledo 2, Ohio, which originally tried plate and bar, but found costs were too high. Revere Product Engineers, Methods and Production Departments collaborated with the company on the problem, and were able to develop the unusually heavy and economical shape. Strong reports a number of savings. One is that the shape is machined quickly and perfectly, with almost no rejects. This is due to the denseness and uniformity of the metal, a result of the high pressures exerted during extrusion. (Finishing operations include drilling bolt holes and cutting cooling fins.) As a secondary result of improved machining, the customer does not have to keep large inventories of metal to take care of spoilage, nor handle large quantities of scrap. Further, Revere supplies the discs in the correct thickness, eliminating a cutting-off operation for Strong. Incidentally, we are glad to supply shapes cut to dimensions, or in long lengths, as desired.

The completed part is an obturator-probe, which fulfills a control and heat dissipation function in a powerful searchlight. Copper was chosen for its ability to conduct heat and resist corrosion. Revere will be glad to collaborate with you in your search for economies through the use of extruded shapes in copper and copper-base alloys, and aluminum alloys.



Copper Extruded Shape, 1 3/16" x 5", as furnished.



Shape in place in a carbon arc searchlight mechanism.

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★ Tensile Strength

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★ Stress-Rupture

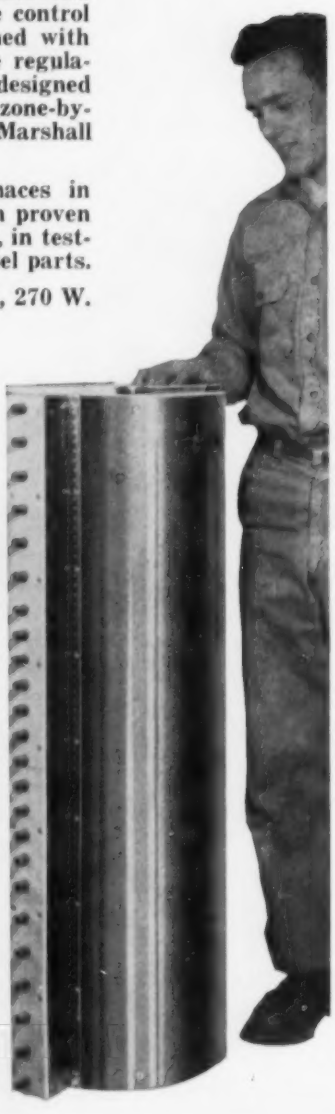
Above are three of the high-temperature tests in which Marshall Furnaces will aid you. These Furnaces enable you to gather accurate data, the only kind you value.

Take creep tests, for example. In these tests Marshall Furnaces provide the evenly-balanced temperature control which it is so important to maintain over long periods. In tensile and stress-rupture tests, too, temperature control is a paramount feature easily attained with Marshall Furnaces. This temperature regulation is due not only to carefully designed spacing of the heating coils, but to the zone-by-zone temperature adjustment only Marshall Furnaces embody.

Engineers are using Marshall Furnaces in many fields of research. They've been proven in atomic energy research, in aviation, in testing jet engine alloys, valve steels, diesel parts.

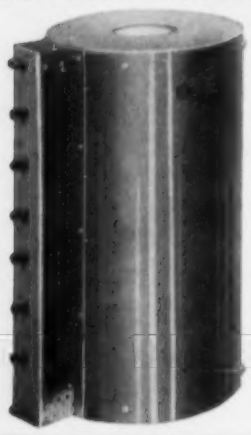
Write direct to Marshall Products Co., 270 W. Lane Ave., Columbus 2, Ohio.

Oversize Marshall Furnaces built to order are shown at right. If required, Furnaces can be designed to your specifications.



Marshall

FURNACES--
CONTROL PANELS



Personals . . .

L. M. Diran is now in charge of cast constructional steel developments for the development and research division of the International Nickel Co., Inc., New York. Mr. Diran joined International Nickel in August 1954 as a research metallurgist in the ferrous casting section of the company's research laboratory at Bayonne, N. J. Prior to that he was a research associate at Massachusetts Institute of Technology.

Harry R. Dahlberg has joined the Braden Copper Co., Rancagua, Chile, S. A., as supervisor of iron, steel and brass foundry operations. He was previously associated with the Warren Foundry and Pipe Corp., Phillipsburg, N. J., as plant manager and the E. W. Bliss Co., Hastings, Mich., as foundry engineer.

Henry M. Heyn, vice-president of the Surface Combustion Corp., Toledo, O., has been appointed general manager in charge of all functions of the Toledo Industrial Div. of the corporation. Other appointments in the management of the division include **Donald Beggs**, formerly assistant research director, now manager of research and development, and **G. J. Langenderfer**, formerly assistant sales manager, now sales manager of the heat treat division.

James B. Fisher recently was appointed district manager of sales in Detroit for the Superior Steel Corp., Carnegie, Pa. Mr. Fisher, who joined Superior 15 years ago, has been located in the Detroit office since 1946.

Robert J. Exter has been appointed vice-president and director of manufacturing of Hunter Engineering Co., Riverside, Calif. Prior to his appointment, Mr. Exter had been associated with the Wyman Gordon Co., Worcester, Mass. for a period of 20 years. He was works manager at the Harvey, Ill. division for 10 years, and in 1954 joined the Worcester division as vice-president of manufacturing. He resigned this position to join the Hunter Engineering Co. at the beginning of this year.

J. D. Cregan, formerly chief project engineer with Aircooled Motors, Inc., Syracuse, N. Y., is now chief engineer.

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and will do thousands of
cutting and forming operations
more economically than carbides

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remember these brand names:

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Wilson "Rockwell"* Hardness Testers

Production line speeds with laboratory accuracy

• There is a WILSON "ROCKWELL"* Hardness Tester to meet every requirement—from laboratory testing to automatic testing at the rate of 1000 pieces per hour.

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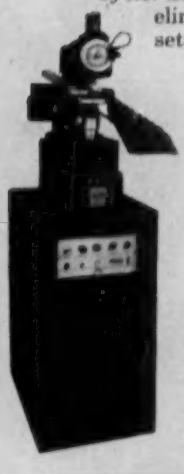
Supplied in both NORMAL and SUPERFICIAL testing types. Designed for testing tools, machine parts and all ferrous and non-ferrous metals, hard or soft, except thin sheet steel.

Y Model Motorized

Suitable for testing work now being done with J models when it is advisable to increase testing speed. Motorized mechanism removes the major load in the test cycle. Set-O-Matic Dial Gauge eliminates need of manually setting dial gauge to zero.



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Executes complete test cycle automatically at the rate of up to 1000 pieces per hour. Will classify tested parts as "correct," "too hard" and "too soft." Controls hardness limits within two Rockwell numbers. Has safety stop if pieces are not fed properly.

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Personals . . .

S. E. Maddigan, formerly assistant director of the department of metallurgical research at the Spokane laboratories of Kaiser Aluminum and Chemical Corp., has been transferred to the Oakland headquarters office, where he will act as a special assistant to the director of the department of metallurgical research, **Paul P. Zeigler**. Before joining Kaiser, Dr. Maddigan served successively as head of the physics and electrochemical research laboratory for Chase Brass and Copper Co. and as director of the British Columbia Research Council.

W. W. Dyrkacz is now manager of quality control at the Watervliet Plant (N. Y.), of Allegheny Ludlum Steel Corp. Mr. Dyrkacz joined the corporation in 1949 as head of the high-temperature alloys section of the Watervliet Plant, and was named associate director of research in charge of high-temperature alloys in 1952. **E. E. Reynolds** has been named associate director of research to fill the vacancy left by Mr. Dyrkacz. Coming to Watervliet in 1950, Dr. Reynolds held the position of supervisor of valve steel research until 1952 when he was named to head the high-temperature alloy section.

Raymond G. Nordstrom has been elected vice-president and general manager of the Reflectal Corp., New York, a subsidiary of Borg-Warner Corp., Chicago. Mr. Nordstrom joined Reflectal as general manager in March 1954 and previously had been assistant to the president of the Ingersoll Products Div. of Borg-Warner.

Robert L. Felt is now chief metallurgist at the Midland, Pa., works of the Crucible Steel Co. of America. Mr. Felt, who joined Crucible in 1951, served as staff metallurgist prior this appointment.

George H. Gough has been appointed assistant product manager by Kaiser Aluminum & Chemical Sales, Inc., with headquarters in Chicago. Mr. Gough went to Kaiser Aluminum from United States Steel Corp., Pittsburgh, where he was product representative for forgings. He is a graduate of Virginia Polytechnic Institute with a B.S. degree in metallurgical engineering.

620 lbs. lighter, more portable, and more durable . . .

Welded Assembly of USS "T-1" Steel Cuts Grapples Weight 47%

It isn't the logs that wear out log grapples like these. But dropping the grapples 10, 25, or 30 feet, twice a minute, hour after hour, day after day, does wear them out. They literally destroy themselves. That's why light weight is important. And toughness. And strength.

Mack Welding Company, Duluth, Minnesota, has cut weight of grapples 620 lbs. and simultaneously *increased* durability, just by switching from mild steel to rugged USS "T-1" Steel. Here is what they say about "T-1":

"We thought we had reached the lowest possible weight when we manufactured a previous model weighing 1300 pounds. But these new grapples made from your 'T-1' Steel weigh only 680 pounds—just a little over half as much. That's an important advantage for loggers who have relatively small-capacity truck-mounted cranes. No other rolled steel plate would give us such light weight in grapples capable of handling up to 3 ton loads."

"T-1" WELDS BEAUTIFULLY!

"As far as fabrication is concerned, we find that 'T-1' Steel welds beautifully and can be flame cut in exactly the same way as mild steel, without distortion or any other difficulty. We're very pleased with it."

"T-1" Steel is unique. For it gives you a combination of high tensile and yield strength (105,000 psi and 90,000 psi), good high temperature strength, extreme toughness at sub-zero temperatures, good resistance to abrasion, impact, and abuse. You get all of these properties in one steel that is easy to weld.

You can use "T-1" to reduce weight . . . to lengthen service life . . . to reduce costs. Look around you. You'll find a job for it—a job that no other steel can do so well. United States Steel, Room 5140, Pittsburgh 30, Pa.

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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

How U. S. Steel's **Robert Blacka** inspects the shaft for America's first full scale atomic power plant

You've read about our nation's first nuclear reactor power plant. It will be operated by Duquesne Light Company at Shippingport, Pa.—near Pittsburgh. Capacity will be a minimum of 60,000 kilowatts, using enriched and natural uranium as fuel, and light water as the moderator.

Westinghouse Electric is building the turbine generator. The first turbine shaft that will be installed is the one in the big picture, a USS Quality Forging being sonic-tested by Robert Blacka who has been a United States Steel Inspector for 16 years.

The instrument sends sound waves through the steel. The waves bounce back from the other side, and the entire journey is shown on the oscilloscope tube. Any imperfection in the steel sends a separate "echo" that can be analyzed by a skilled inspector.

Of course, there are other tests: macro-etching and microscopic examination, physical testing of bars to determine strength levels and ductility, magnetic particle and borescope inspection plus others—depending on customer needs.

USS Quality Forgings are very frequently specified when the buyer cannot tolerate the slightest compromise with quality. Part of the reason lies in United States Steel's complete array of test facilities—in the hands of seasoned inspectors who know how to use them.

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- forged steel rolls and back-up roll sleeves
- electrical and water wheel shafts
- specialty forgings of all types

UNITED STATES STEEL

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

"We've found that refractory concrete furnace walls like this have a better K insulating value than conventional masonry walls," reports masonry superintendent Floyd Colledge, Homestead Works, United States Steel Corp., Munhall, Pa. Packaged castable used on this job: Laclede-Christy's "Steel Cast."

50-foot furnace side walls still like new after 4 years of service at 2200°F.

"We build our long furnace walls of anchored refractory concrete for greater stability and increased resistance to thermal stresses and strains," reports masonry superintendent Floyd Colledge. "Some of these refractory concrete walls have been in service over 4 years and are still in excellent condition."

Refractory concrete furnace walls made with Lumnite* calcium-aluminate cement or Lumnite-base castables can save time and money in your plant, too. Construction is fast and easy—just pour refractory concrete in simple wooden forms. No costly fitting at joints or around portholes. And refractory concrete made with Lumnite reaches service strength within 24 hours!

You'll find many other uses for refractory concrete made with Lumnite. And you can make refractory concrete *designed for your specific job* by just adding water to a factory-prepared castable mix. Keep a supply of Lumnite cement or Lumnite-base castables on hand for emergency needs. Castables are made and distributed by leading manufacturers of refractories.

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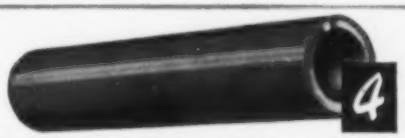
7 WAYS to SAVE MONEY with TOCCO* Induction Hardening

Cost was reduced 94% when heat-treatment of this corn-harvester part was changed from carburizing to TOCCO-hardening, 9½c saved on every piece — $4750 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour.

Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of $375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.

Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from $1.57 to 10c apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11c per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.



Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from $5.45 to $3.25 per hundred parts—a savings of 2c per pin, $26.40 per production hour.

Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4c per piece—$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.

7

Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for similar cost-saving results—without obligation, of course.

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The handy Alnor Pyrocon is unequaled for quick, accurate reading of all surface temperatures . . . whether they are metallic or non-metallic, flat or curved, stationary or revolving. Accurate temperatures are easily understood on the Pyrocon's direct reading scale face . . . without interpolation or need of conversion tables. A wide selection of thermocouples and extension arms permits adaptation to many types of service. For complete details and prices, send for Bulletin No. 4257. Illinois Testing Laboratories Inc., Room 523, 420 N. LaSalle Street, Chicago 10, Ill.

Alnor

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Personals . . .

Leonard A. Abrams, formerly with the Savannah River Operations Office, U.S. Atomic Energy Commission, has accepted the position of supervisor of fabrication with Babcock & Wilcox Co., in the new nuclear fabrication plant in Lynchburg, Va.

Gilbert Soler has been appointed technical director of the Universal-Cyclops Steel Corp., Bridgeville, Pa. Prior to his recent appointment, Mr. Soler was assistant technical director.

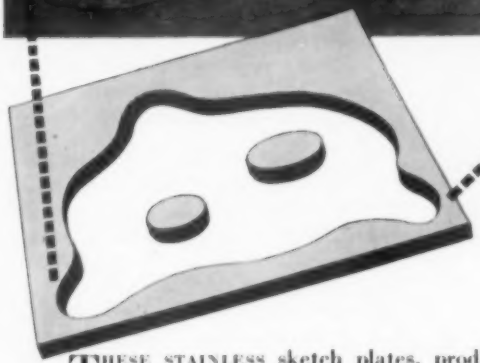
Homer C. Hueffed, formerly quality control supervisor for the Leece-Neville Co., Cleveland, has been appointed superintendent of the company's Hamilton Ave. plant. Mr. Hueffed has been with the Leece-Neville Co. in various engineering and supervisory capacities since 1944.

Van H. Leichliter, vice-president of operations of the American Steel and Wire Div., United States Steel Corp., Cleveland, has been elected vice-president of the American Standards Association.

Frank E. Garratt has been named works manager of the Bridgeville, Pa., plant of the Universal-Cyclops Steel Corp. Mr. Garratt has been associated with the corporation for 21 years and prior to his appointment held the position of general superintendent.

Ulric R. Jaeger, recently appointed sales engineer of the Roll Bond Dept. of the Metals Div., Olin Mathieson Chemical Corp., East Alton, Ill., has been named acting sales manager for Olin Roll Bond products. Prior to joining Olin Mathieson last year, Mr. Jaeger was assistant to the president and general manager of Superior Bearing Bronze Co., New York.

David B. Carson was recently elected executive vice-president of the Sharon Steel Corp., Sharon, Pa. Active in the steel business since 1915, Mr. Carson has been associated with Sharon Steel since 1930. He has served as vice-president since 1937 and is now a director of Mallory-Sharon Titanium Corp., Steel Trucking, Inc., Joanne Coal Co., and Carpentertown Coal & Coke Co.



This customer saved 46% in freight charges

on these stainless steel plates

THESE STAINLESS sketch plates, produced by G. O. Carlson, Inc., saved the customer 46% in shipping costs. If he had bought rectangular plates and done his own cutting, he would have paid freight on excess material which he could not use.

Then too, cutting and machining facilities were quite limited at the job site. Time and money were saved by having Carlson cut and machine the plates to the accurate tolerances specified.

For your next work involving stainless steel plates, heads and other stainless products, let us show you how—*and how much*—you save by buying from G. O. Carlson, Inc.

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Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

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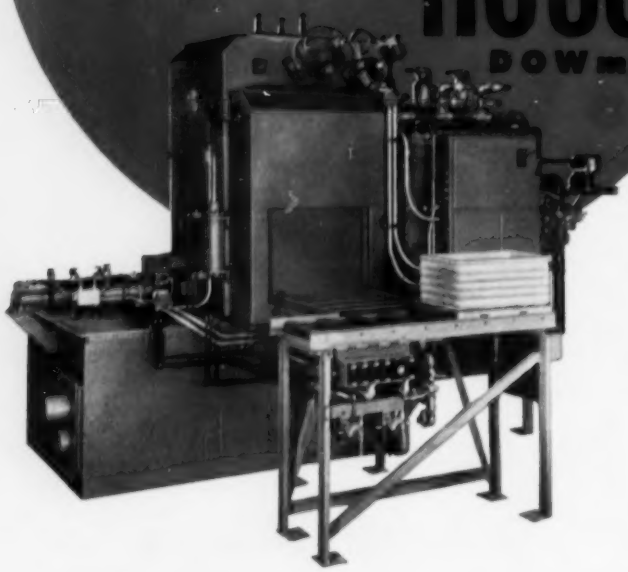
DOWmatic



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First WITH MECHANIZED, BATCH-TYPE, CONTROLLED ATMOSPHERE FURNACES

Personals . . .

John C. McDonald, formerly assistant technical director and head of the metallurgical laboratory of the magnesium department, Dow Chemical Co., Midland, Mich., will now devote full time to the position of assistant technical director and will become a member of the Magnesium Administrative and Planning Group. **Robert S. Busk**, formerly assistant head of the magnesium department's metallurgical laboratory, will succeed Dr. McDonald as head of the laboratory.

Rudolf H. Thielemann, manager of Stanford Research Institute's metallurgical section, Menlo Park, Calif., has been appointed to the National Advisory Committee for Aeronautics. Thielemann was named to the committee on power plants for aircraft and designated chairman of the subcommittee on power plant materials.

E. R. Mertz is now head of the materials engineering department at Aerojet's Liquid Rocket Plant in Sacramento, Calif. Previously, Mr. Mertz was associate professor of general engineering at the University of Southern California and was a Fulbright professor at the University of Adelaide, Australia for the year 1953-54.

Edgar C. Wallace has resigned as metallurgist at the Barber-Colman Co., Rockford, Ill., to accept the position as chief metallurgist of the New York Air Brake Co., Watertown, N. Y. Mr. Wallace, prior to his resignation, was the chairman of the Rockford Chapter of A.S.M. He also serves on the A.S.M. Committee on Literature Classification.

Desmond S. Chambers is now plant metallurgist at Vanadium-Alloys Steel Co.'s high speed steel mill at Latrobe, Pa. After his graduation from Case Institute of Technology in 1950, Mr. Chambers joined the research staff of Vanadium-Alloys and later transferred to the metallurgical service department.

James L. Wyatt has been appointed head of the department of metallurgical engineering of Horizons, Inc., Cleveland. Dr. Wyatt was formerly technical director of the organization.

In goes the new Rolock "Neu-pot"—into one of Eastern Heat Treating and Brazing Company's neutral-salt-bath furnaces. It's made of ¼" Inconel plate, welded to an Inconel head, flanged and dished by Lukens Steel Co. X-ray inspection insures sound, non-porous welds. For complete data, write Rolock Incorporated, Fairfield, Conn.

New, wrought Inconel pots give low cost-per-hour neutral-salt operation

Rolock's "Neu-Pot" chalks up 3300 hours without sign of failure

Now, with a new wrought Inconel* nickel-chromium alloy pot, you can expect long, dependable service from neutral-salts bath equipment.

The new unit (called the "Neu-pot" because it's intended for neutral-salt furnaces) was designed and fabricated by Rolock, Inc., Fairfield, Conn.

More than a year ago, one of the first Inconel nickel-chromium alloy units was installed at Eastern Heat Treating & Brazing Corp., New York, N. Y. No sign of failure yet, despite two-shift service at 1525°F. Previously Eastern often replaced pots within four months . . . sometimes within 500 hours. Sometimes sudden failures even ruined furnace linings.

Now, with Inconel, Eastern Heat Treating gets long, *dependable* salt-pot life . . . and a low cost-per-hour operation.

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67 Wall Street New York 5, N. Y.
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Inconel... *for long life at high temperatures*

Want more life from your heat-treating equipment?

Here are two suggestions.

First, look into Inconel... retains high strength at high temperatures, resists corrosive attack by most heat-treating atmospheres, easily fabricated.

Second, send for "Keeping Operating Costs Down When Temperatures Go Up," Inco booklet packed with ideas for improving life and operation of heat-treating equipment, fixtures.

INCO Nickel Alloys

If you're suffering from tired metals, weak metals, corroded metals—or some other costly metal ailment—it will pay you well to put in a call to a metals specialist today. May we suggest Riverside? Our metallurgists *are* specialists. And Riverside's experience in non-ferrous alloys spans more than a century. Experience, incidentally, that is yours for the asking.

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Hartford • Cleveland • Chicago • Detroit
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PHOSPHOR BRONZE AND NICKEL SILVER SHEET, STRIP, WIRE AND ROD

Personals . . .

Lawrence F. Boland, vice-president, sales, of the Beryllium Corp., Reading, Pa., has been elected a director by the board of the corporation. Mr. Boland, who has been with Beryllium since 1935, was sales manager for three years before becoming a vice-president last March.

William P. Askew, who has been employed in the specialty division of the Park Chemical Co., Detroit, will now work out of the home office as sales representative, heat treating materials division.

Elmer B. Dunkak recently was elected to the newly created position of vice-president, sales with the Selas Corp. of America, Philadelphia. For the past 18 months Mr. Dunkak has served Selas as consultant to the president. Prior to joining the corporation, he was engaged in private practice, specializing in management problems relating to products and marketing.

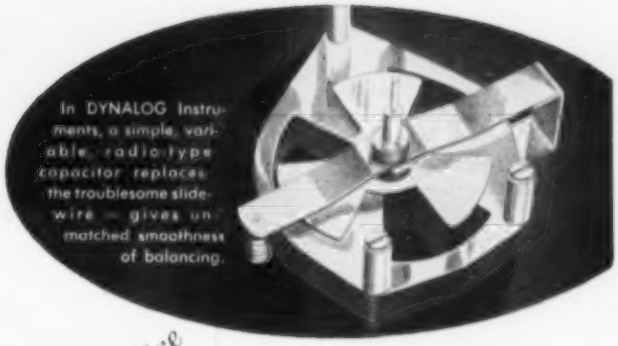
Sidney J. Barber, formerly supervisor of metal working research at E. F. Houghton & Co., Philadelphia, has been named manager of the metal working products department. Mr. Barber has been with the company for 30 years.

Robert H. Settles has joined the Park Chemical Co., Detroit, as sales representative of the heat treating materials division in the New England states. Previously, Mr. Settles was associated with Babcock and Wilcox, Solar Steel Co., and Jos. P. Ryerson & Sons, Inc.

Edward J. Schultz, an abrasive grain specialist, has been assigned to the field by the electro minerals division of the Carborundum Co., Niagara Falls, N. Y. Mr. Schultz will service the Michigan and Toledo, Ohio area in his new position.

John R. Bremer, formerly assistant purchasing agent of SKF Industries, Inc., Philadelphia, has been appointed purchasing agent for the company.

Arthur P. Guidi recently joined the management of Texas Foundries, Inc., Lufkin, Texas, as assistant to the plant manager. Mr. Guidi was formerly employed by the Texas Electric Steel Castings Co., Houston, Texas.


In DYNALOG Instruments, a simple, variable, radio-type capacitor replaces the troublesome slidewire — gives unmatched smoothness of balancing.

This potentiometer has no slidewire

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- no slidewire
- no batteries
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- no gears, cables, etc.
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There's no need to put up with worn slidewires and sticking electrical contacts . . . no need to periodically clean and lubricate balancing motors. DYNALOG design eliminates all this! Its simple variable capacitor and positive magnetic drive provide *continuous, stepless* balancing . . . *never* require attention!

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DYNALOG Instruments are available for use with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable . . . with unmatched smoothness. Write for Bulletin 427. The Foxboro Company, 524 Neponset Ave., Foxboro, Mass., U.S.A.

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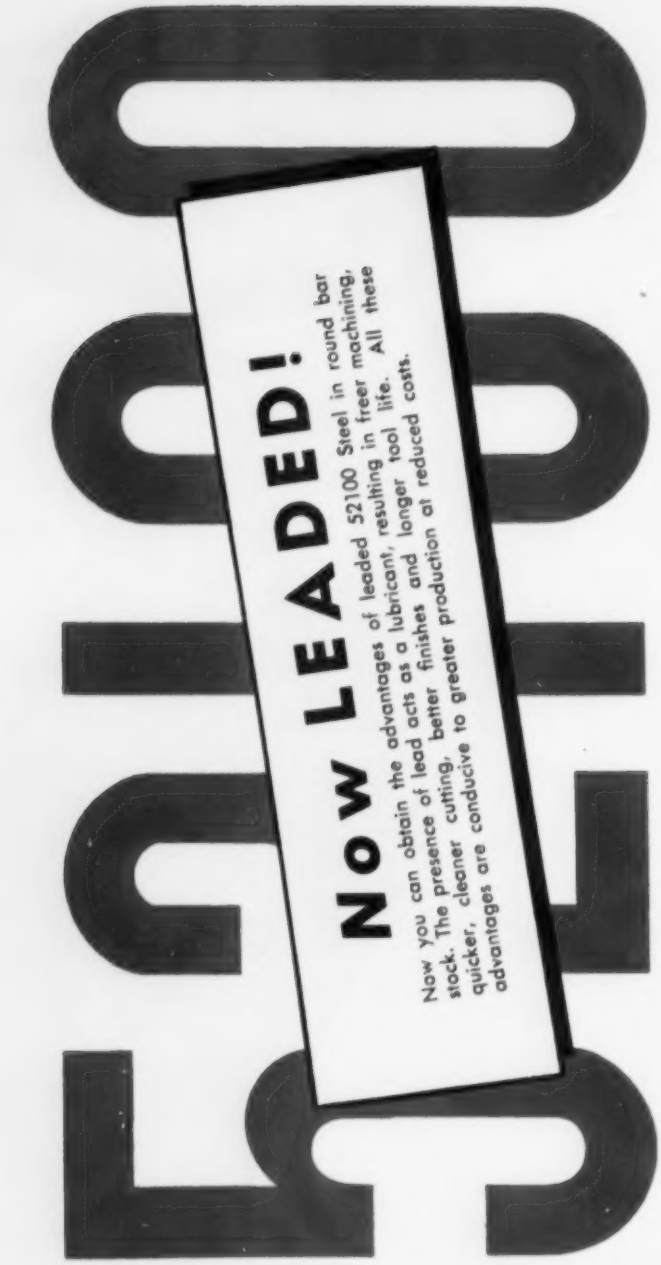
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Personals . . .

Michael C. McFadden, Jr. has been appointed to the central Atlantic Coast technical field section of the International Nickel Co.'s development and research division. Before joining Inco, Mr. McFadden was associated with the Chevrolet-Detroit Gear and Axle Div. of General Motors Corp., for over six years, attaining the position of supervisor in the plant engineering department.

Andrew R. Spencer has announced the formation of Precision Testing Laboratories, Inc., Detroit, as consulting metallurgists and chemists offering general metallurgical and chemical laboratory facilities, research programs and product development. Mr. Spencer formerly was associated with Steel Sales Corp., Detroit, for seven years as nickel alloys specialist.

Richard L. Jones, formerly on the research staff of General Motors Corp., Detroit, is now a metallurgist in the engineering test laboratory of the Convair Div., Fort Worth, Tex., of the General Dynamics Corp.

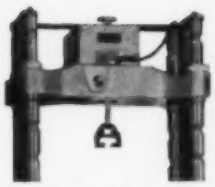
James E. Thayer, a June 1955 graduate of the University of Southern California, is now working in the applied metallurgy section of the Atomic Power Division, Westinghouse Electric Corp., Pittsburgh. Mr. Thayer is also attending graduate night courses in metallurgy at Carnegie Institute of Technology.

R. F. Wilde, a recent graduate of Massachusetts Institute of Technology, has accepted a position as experimental metallurgist at the Allison Division, General Motors Corp., Indianapolis, Ind.

Harry A. Scullon is now superintendent of inspection and quality control at Northeastern Steel Corp., Bridgeport, Conn. Prior to this position, Mr. Scullon was associated with the metallurgical research division, SKF Industries, Inc., Philadelphia.

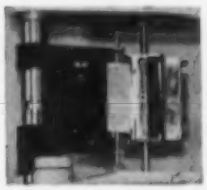
George Perrault, Jr., manager of the Salem, Ohio, rolling mill division of E. W. Bliss Co., has been appointed a vice-president of the company. Mr. Perrault joined Bliss as sales manager of the rolling mill division in 1949 and was appointed manager of the division in 1954.

Here's Proof of the Unmatched Testing Versatility At Your Command . . . . . with an OLSEN

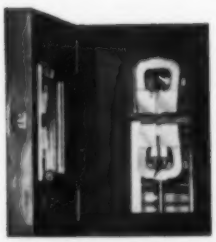


With a LOAD CELL, ranges as low as 0 to 5 lbs. represent full dial scale on even the largest Olsen.

12,000 lb. cap. Electromatic U.T.M.



HIGH TEMPERATURE FURNACE for testing at up to 2,000°F.



COLD AND HOT TESTING in a single cabinet from −75° to 600°F.

STRAIN RATE INDICATOR enables operator to adjust testing speed in terms of actual specimen strain (in./in./min.).

AUTOMATIC PROGRAM CONTROLLER for accurately conducting production, proof or various cycling tests to preset controls.

Other Standard Olsen Accessories

- Over 30 different EXTENSOMETERS available for measuring strain in conjunction with a Model 51 recorder.
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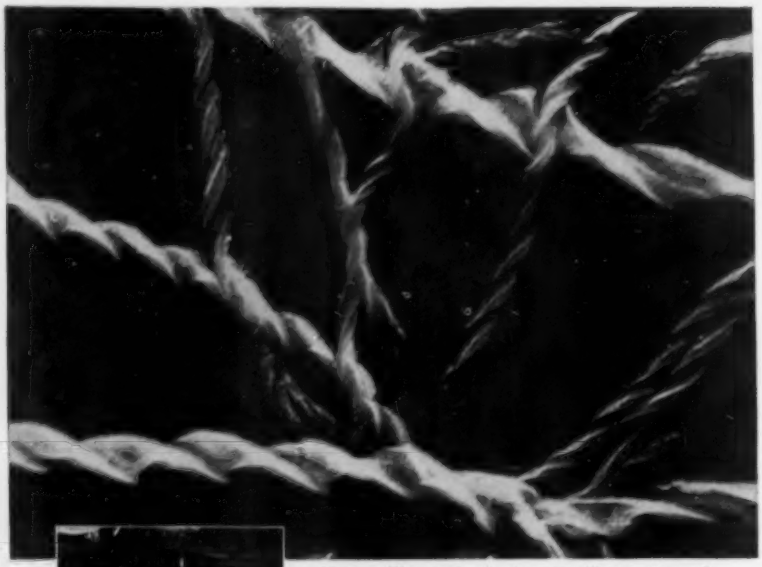


Electron Micrograph showing rope-like structure of lithium stearate.

Atlantic predicts BEHAVIOR of GREASES aided by RCA ELECTRON MICROSCOPE

Dr. Simard and microscopist.

Basic studies with the RCA Electron Microscope under the immediate supervision of Dr. Roger G. Simard, of The Atlantic Refining Company Research Laboratories, Philadelphia, have brought the grease system into microscopic focus. Today's high-speed precision machinery demands specialized greases that will withstand extremely severe operating conditions. An ordinary lubricating grease is a suspension of metal soap fibres in a lubricating oil. Distributed uniformly throughout the oil, the soap fibres hold the oil between them, principally by capillary attraction. By studying these soaps with the electron microscope, scientists are able to correlate their structure with the physical properties and behavior of the finished grease. Thus, it is possible to screen out defective batches and to set up standards of quality leading to the development of new and better greases.

The latest word for fundamental research on crystalline structures, diverse solids, metallurgical and geological specimens, tissues, bacteria and viruses, the new RCA Electron Microscopes provide magnification and resolution higher than ever before possible and include many advanced engineering features. Why not find out more about these wonderful instruments? Installation supervision is supplied, and contract service by RCA Service Company is available if desired.

For further information on the use of the RCA Electron Microscope, write to Dept. D-72, Building 15-1, Camden, N.J. In Canada: RCA VICTOR Company Limited, Montreal.

Electron Microscopes

RADIO CORPORATION of AMERICA

Personals . . .

Gary W. Wilson has been transferred to the Philadelphia sales office of the American Brass Co. Since joining the company in April 1954, Mr. Wilson has spent most of his time in the sales training program in the Connecticut mills.

W. C. Pine, formerly a metallurgist for the Universal Winding Co., Cranston, R. I., is now chief metallurgist for C. I. Hayes, Inc., Providence, R. I.

Richard S. Cremisio, recently discharged from the U. S. Army, is now a graduate student in metallurgical engineering at Rensselaer Polytechnic Institute. While in the Army, Mr. Cremisio served as metallurgical consultant at the Army Chemical Center in Maryland and taught evening classes at the graduate extension division of the University of Maryland which is located at the Center.

R. Terrence Webster resigned his position with the Nordstrom Valve Division, Rockwell Manufacturing Co., Oakland, Calif., to join the Atomic Power Division of Westinghouse Electric Corp., Pittsburgh, as a metallurgical engineer.

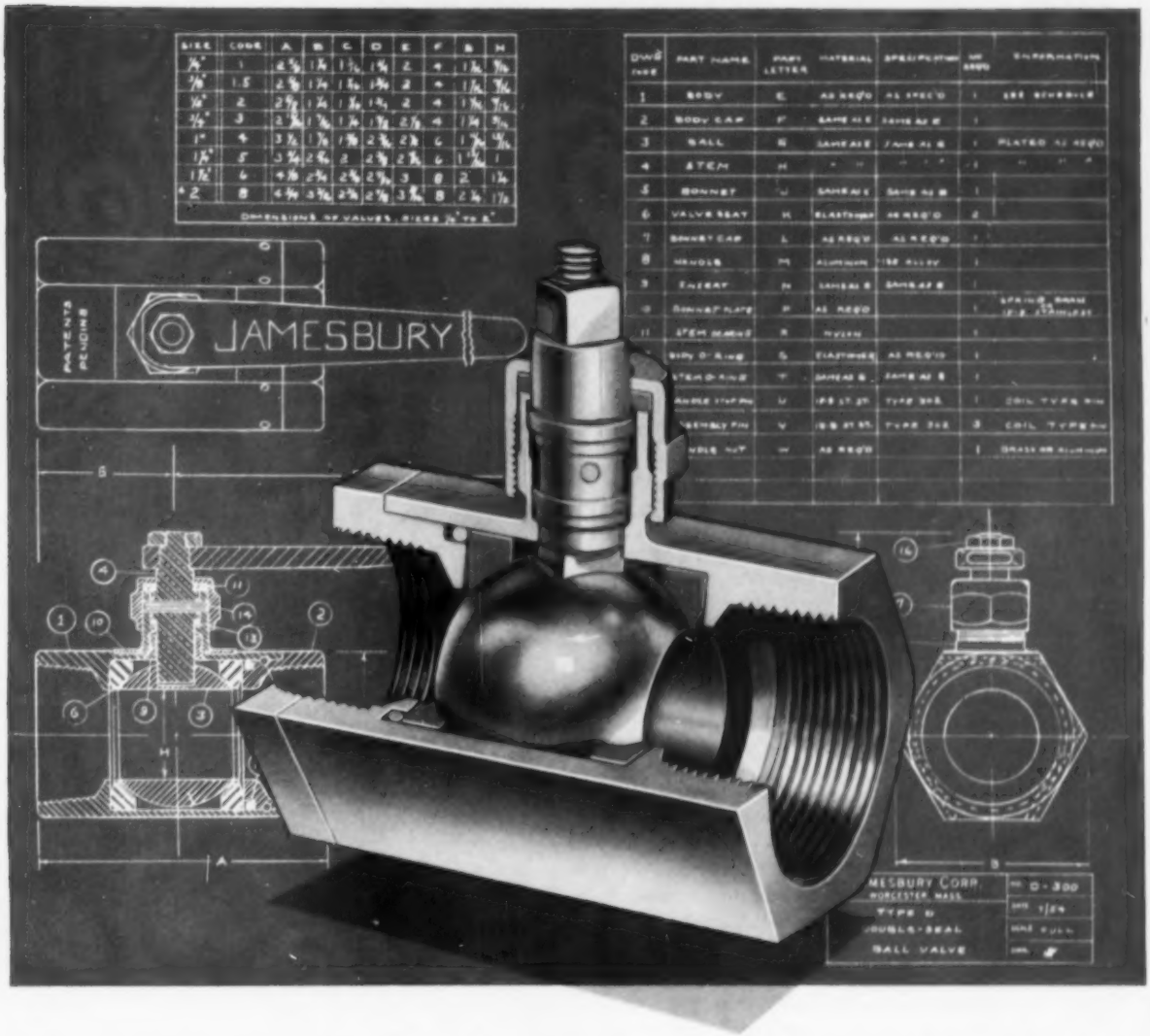
Fred C. Valentin, formerly a manufacturing engineer with the Greer Hydraulics Corp., Idlewild, N. Y. has joined the Blackstone Corp., Jamestown, N. Y., as manager of methods engineering.

Carl R. Loper, Jr. is a full-time instructor in foundry metallurgy in the department of mining and metallurgy at the University of Wisconsin. Mr. Loper was formerly with the Pelton Steel Casting Co., Milwaukee, Wis.

Donald W. Stoffel, a recent graduate of the University of Tennessee, is employed as a metallurgist with the metal products division of Koppers Co., Baltimore, Md.

Carl J. Winkler Sr. has retired as vice-president of the Stewart Warner Corp. Mr. Winkler was president and treasurer of the U. S. Machine Corp., Lebanon, Ind., for 18 years, until it was absorbed by the Stewart Warner Corp. Prior to this, he had spent 18 years with the Schwitzer-Cummins Corp., Indianapolis, Ind.

New, all-stainless double-seal ball valve. Its manufacturer, JAMESBURY CORPORATION, Worcester, Mass., stresses its straight-line flow and elimination of practically all maintenance.



STAINLESS means corrosion-resistance in new double-seal ball valve...

The *all-stainless* construction of this new-type, double-seal ball valve means exceptional resistance to corrosion, erosion and abrasion. That's part of the reason why these Jamesbury valves are being used for chemical applications... processing of hot caustic solutions... even for the vacuum fields.

The valve differs from conventional globe or gate valves in that its operation depends upon a stainless steel ball, sealed with a plastic or rubber ring on both sides. All of the valve, including the ball, is machined from Crucible stainless bar stock, type 303 or 316.

Stainless may be the answer for your product, too. Why not let a Crucible engineer give you the facts concerning its most profitable use? *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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QUALITY
CONTROL
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Myriads of details go hand in hand with Quality Control. For one example, at the onset of production, a casting is "destroyed" by sectionalizing to determine dimensional accuracy. Irregularities can be corrected, molding methods acknowledged, and the general structure can be proved before subsequent costs are expended.

As illustrated above, the transparent "sectional template" visually approves interior members and voids, as well as outlines finish surface adequacy for the record.

Complete progress is recorded, and any time after inception —costs, revisions, equipment function, production details . . . and even difficulties encountered can be itemized with exactness.

It all adds up to *top quality control* service. This service can be *your* service. Write or call for complete information.

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Unitcast

QUALITY
STEEL
CASTINGS

Personals . . .

James T. Shapland is now working as a foreman in the ceramicast department of the Lebanon Steel Foundry, Lebanon, Pa. Mr. Shapland left the International Harvester Co. when its Evansville, Ind. plant was closed.

Edward E. Reynolds has been named associate director of research for high-temperature and valve alloys at Allegheny Ludlum Steel Corp., Watervliet, N. Y. Prior to his recent appointment, Mr. Reynolds was supervising metallurgist for six years with the same company.

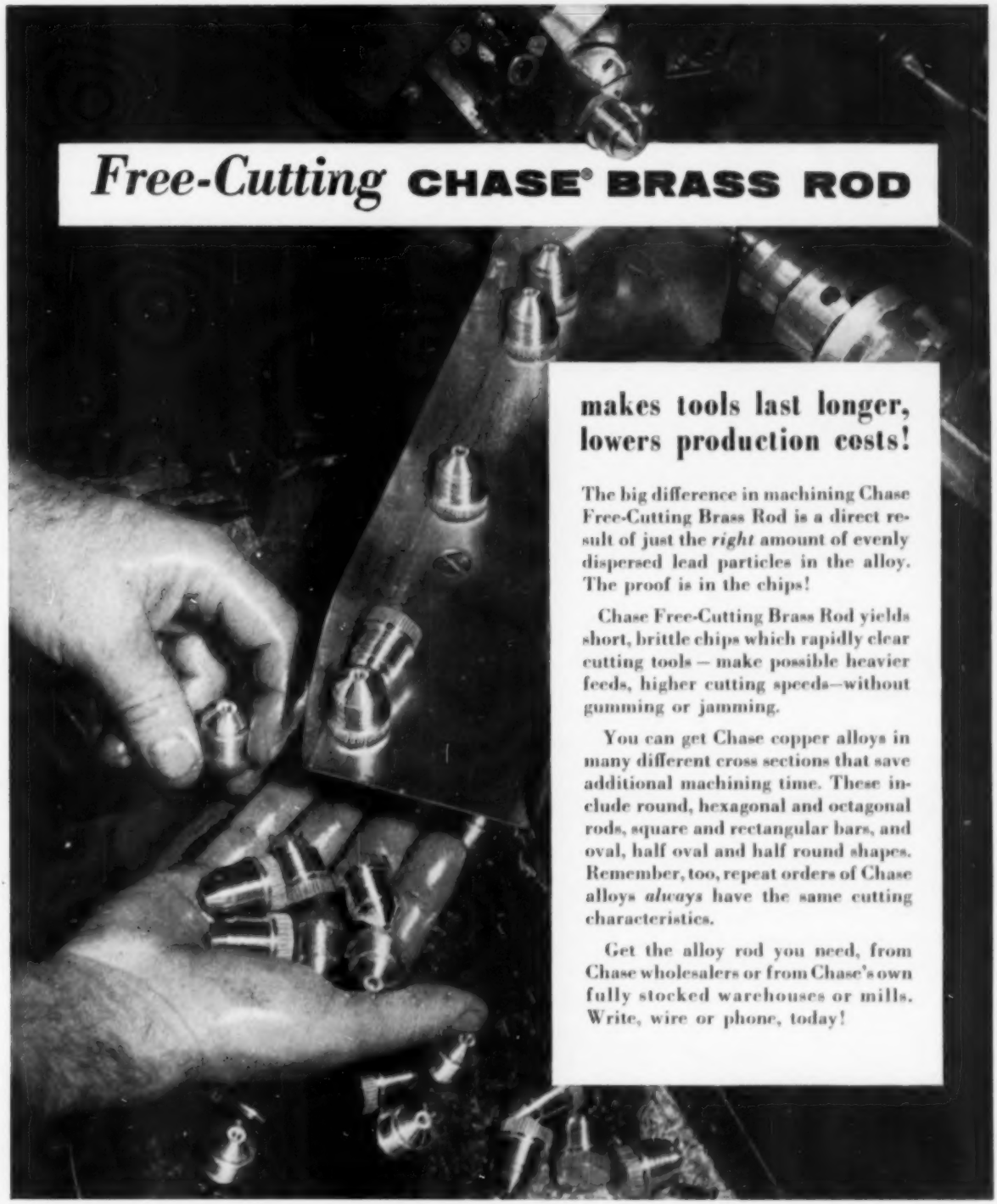
Thomas D. Cooper has taken military leave of absence from the Westinghouse Electric Corp., Pittsburgh. Lt. Cooper is now serving as project officer, light alloys section, metals branch of materials laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

Harry P. Dobrow has joined the advanced reactor development department of the atomic power division of the Westinghouse Electric Corp., Pittsburgh. Mr. Dobrow was formerly assistant to the vice-president of the Alloy Engineering and Casting Co., Champaign, Ill. and also assistant chief engineer, aircraft castings design, with the same company.

George J. Basl is now employed in the materials and processes department at the Rocketdyne Div., of North American Aviation, Inc., Canoga Park, Calif.

Jerome M. Mann as at present on active duty with the U. S. Air Force. Mr. Mann is assigned to supply school at F. E. Warren Air Force Base, Wyo. for further assignment to the Far East. He plans to return to the Reynolds Metals Co. when his military service is completed.

Stanley L. Channon has joined the staff of Hunter Engineering Co., Riverside, Calif. Dr. Channon came to the United States from Australia in 1947 to pursue graduate studies in metallurgical engineering. After receiving his Ph.D. at the University of Illinois, he joined the E. I. du Pont de Nemours & Co., Wilmington, Del. and later was employed by Kaiser Aluminum and Chemical Corp., Spokane, Wash.



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makes tools last longer, lowers production costs!

The big difference in machining Chase Free-Cutting Brass Rod is a direct result of just the *right* amount of evenly dispersed lead particles in the alloy. The proof is in the chips!

Chase Free-Cutting Brass Rod yields short, brittle chips which rapidly clear cutting tools — make possible heavier feeds, higher cutting speeds—without gumming or jamming.

You can get Chase copper alloys in many different cross sections that save additional machining time. These include round, hexagonal and octagonal rods, square and rectangular bars, and oval, half oval and half round shapes. Remember, too, repeat orders of Chase alloys *always* have the same cutting characteristics.

Get the alloy rod you need, from Chase wholesalers or from Chase's own fully stocked warehouses or mills. Write, wire or phone, today!

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NEW CHASE ROD and WIRE MOVIE "IN THE CHIPS"

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. . . with J-M 3X Blazecrete® the hydraulic setting refractory

You can make longer lasting linings for ladles with J-M 3X Blazecrete, because it is spall-resistant, withstands slagging action and has negligible shrinkage.

3X Blazecrete . . . the 3000F refractory . . . is easily and quickly applied . . . mix with water like ordinary concrete, and slap-trowel to desired thickness. Hardens without application of heat. Contains no harmful irritants . . . safe even for hand application. 3X Blazecrete is furnished as a dry mix, and may be stored indefinitely without deterioration.

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Send for free brochure on Blazecrete (RC-28A) describing its properties and uses. To obtain your copy—as well as additional application details—write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 565 Lakeshore Road, Port Credit East, Ontario.

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Johns-Manville BLAZECRETE

BUILDS BETTER REFRACTORY LININGS

Personals . . .

Paul J. Niquette, a June 1955 graduate of Illinois Institute of Technology, is now employed as a metallurgical trainee at the South Works of U. S. Steel Corp., Chicago.

John M. Lessells has retired from active teaching at the Massachusetts Institute of Technology and is devoting his time to the consulting firm of Lessells and Associates, Inc., Boston. He is the president of the firm.

Gedale D. Davis has been released from active duty with the U. S. Navy and is now a metallurgical trainee at the Baltimore, Md., plant of the Kaiser Aluminum and Chemical Corp.

R. J. Hayes is engaged in jet pilot training at Laughlin Air Force Base, Del Rio, Tex. Lt. Hayes was formerly employed as a metallurgical engineer by the Raytheon Manufacturing Co., Wayland, Mass.

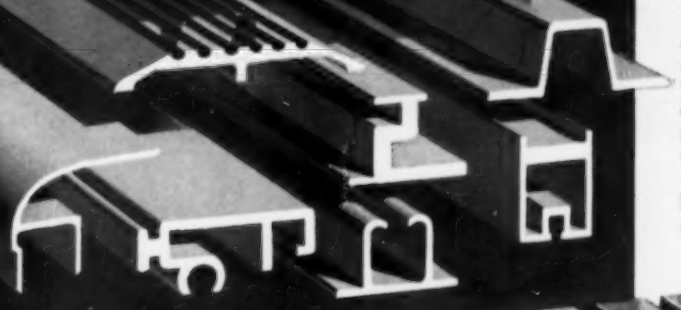
Glenn F. Whiteley has been transferred from the Bridgeport, Conn. plant of Heppenstall Co. to the Indianapolis, Ind. plant of the same company. Mr. Whiteley is chief metallurgical engineer at the Indianapolis plant.

Paul E. Mueller has accepted the position of remelt metallurgist with Kaiser Aluminum and Chemical Corp. at the Halethorpe, Md., extrusion plant. Prior to this position, Mr. Mueller was a research and development metallurgist for Republic Steel Corp., Canton, Ohio.

Erich Meinhard, formerly a member of the metallurgical staff of Lindberg Steel Treating Co., Chicago, has been transferred to the Lindberg plant in Los Angeles as plant metallurgist. Prior to joining the Lindberg Steel Treating Co., Mr. Meinhard was employed as research metallurgist by Rheinische Roehrenwerke A. G., Dusseldorf-Rhine, West Germany.

John E. Newlin, Jr. has been appointed manager of toolsteel sales by the Carpenter Steel Co., Reading, Pa. Mr. Newlin joined Carpenter after 15 years with Henry Disston & Sons Co., Inc., Philadelphia, and last held the position of manager of sales of both the steel and armor divisions of Disston & Sons.

REVERE



It is Revere's business to supply you with metals that can keep your production flowing smoothly. In Revere Aluminum Extrusions you get metals made with a skill that comes only from many years' experience, plus service and delivery that come from Revere's undivided interest in filling your needs. It will pay you to gear the progress of your business to the most dependable sources of supply.

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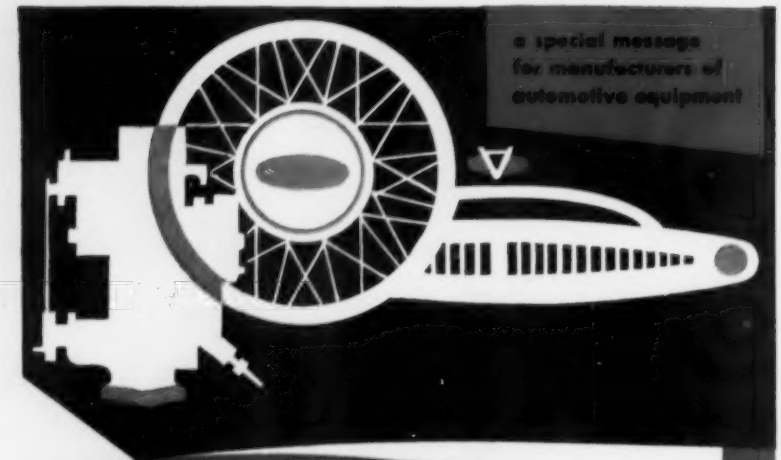
Revere Aluminum Mill Products include extruded products; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn tube and welded tube; rolled shapes; electrical conductors; forgings; and foil. Call the nearest Revere Sales Office now. They are in all principal cities. Revere Copper and Brass Incorporated. *Founded by Paul Revere in 1801.* Executive Offices: 230 Park Avenue, New York 17, N. Y.

EXTRUSIONS



need a finish for low cost corrosion protection or showroom sparkle?

specify IRIDITE

Whether you're finishing non-ferrous parts for high corrosion protection, paint base, or for showroom sales appeal, you can be sure of low material and production costs and peak performance when you specify Iridite. Here's what you can do with Iridite:

- **ON ZINC AND CADMIUM** you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.
- **ON COPPER . . .** Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.
- **ON ALUMINUM** Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.
- **ON MAGNESIUM** Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals, ARP Plating Chemicals

Personals . . .

Clarence J. Miller, formerly chief metallurgist at the Kaiser-Frazer Corp., Willow Run, Mich., is now a metallurgical specialist in the development engineering section of the jet engine division of the General Electric Co., Cincinnati, O.

William A. Token is a process analyst in the process control department of Consolidated Vultee Aircraft Corp. Formerly, Mr. Token was a laboratory technician in the metal department of the steam turbine division, South Philadelphia Works, Westinghouse Electric Corp.

Jess N. McCombe has been appointed district sales manager of the Milwaukee branch for the Wisconsin territory of Columbia Tool Steel Co., Chicago Heights, Ill. Mr. McCombe joined the company in February 1952 as a service technician in the Chicago area.

John D. Berwick, Jr., formerly assistant to the works manager of the Seymour Mfg. Co., Seymour, Conn., has been appointed general superintendent in charge of the manufacturing division.

John J. Stobie, Jr. has been appointed west coast sales manager, Long Beach, Calif., for the Apex Smelting Co.

T. E. Rybka has been named assistant sales manager, special products division, American Cast Iron Pipe Co., Birmingham, Ala.

Aaron Wachter, corrosion department, Shell Development Co., Emeryville, Calif. has been given the 1955 Outstanding Service Award of the Western Region of the National Association of Corrosion Engineers.

John L. Cotsworth has been named manager of sales for the Northeastern Steel Corp., Bridgeport, Conn. Before joining the corporation, Mr. Cotsworth was associated with Atlas Steels, Ltd.

Max Huber is now employed as a metallurgical engineer in the special steel division of Union Carbide Europe, Geneva, Switzerland. Mr. Huber was previously associated with the Battelle Institute in Geneva.

R. N. Sebris is now chief engineer at Eastern Air Devices, Inc., Dover, N. H.

Expert Salem-Brosius Engineering
SOLVED
This Tough Heat-Treating Problem

The complex battery of pit-type heat-treating furnaces shown above, drawn to scale and cut away to show the heating action, was designed and erected by Salem-Brosius. They are radiant-tube, gas-fired, forced-circulation furnaces designed to anneal and normalize helicopter propeller tubes and other tubular section in a nitrogen atmosphere.

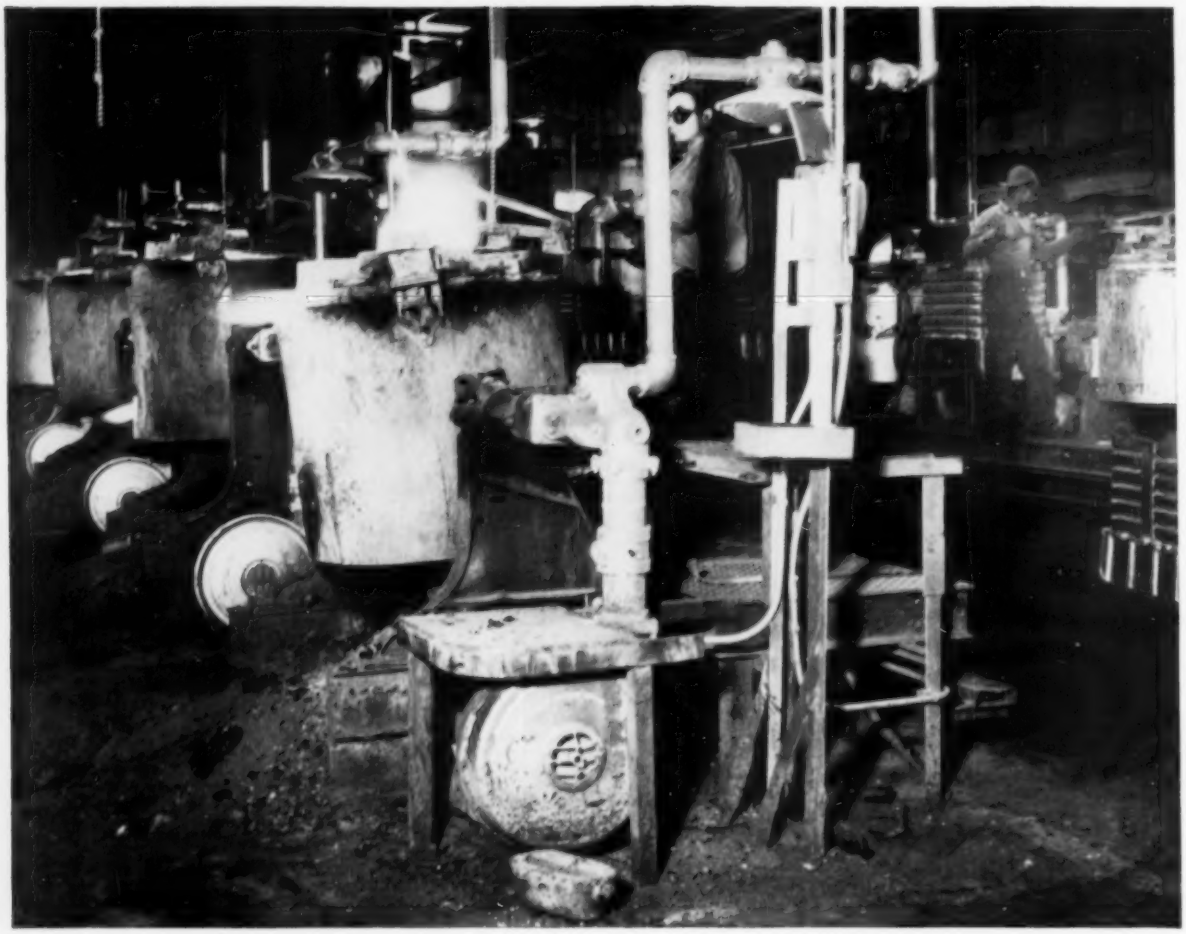
The first two furnaces in the battery anneal at 1350°F both round and elliptical alloy steel tubes at the rate of 1200 lb per hr. The third furnace has an equal capacity, but normalizes the tubes at 1850°F. These furnaces will handle lengths from 3 to 15 ft and diameters from 6 to 18 in., with either uniform or varying wall thicknesses. Elliptical tubes may range up to 22 in. on the major axis by 10 in. on the minor axis. The equipment seen in the background includes a nitrogen gas generator and gas scrubbing, refrigerating and drying units.

We think you'll agree that in successfully solving this heat-treating problem, Salem-Brosius has the experience and know-how to solve yours. Write to us.

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

IN CANADA: SALEM ENGINEERING LTD. · 1525 BLOOR STREET WEST, TORONTO 9, ONTARIO



Schaible Company finds Blowers that can take it

The air in this typical production foundry is full of sand and dirt—but North American blowers, designed for heavy duty, give constant pressure year-in and year-out, even on these really tough jobs. Foundry success depends on steady operation—steady blower operation.

All 18 Campbell-Hausfeld tilting crucible furnaces in this brass foundry use:
North American No. 300 Turbo Blowers
North American No. 65 Aspirator Mixers
North American
No. 18 Atmospheric Regulators
North American No. 25 Butterfly Air Valves

For Better Blowers – Buy North American

NORTH AMERICAN COMBUSTION since 1917

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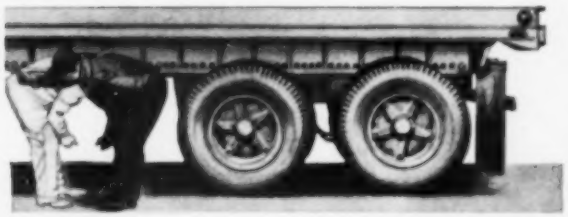
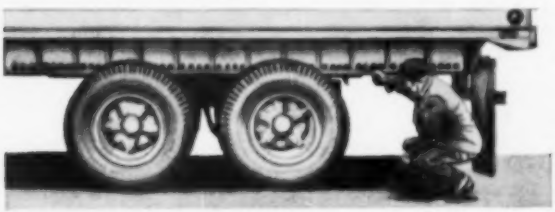
4455 East 71st St. • Cleveland 5, Ohio

Wrought Everdur* Cuts Cost in Half



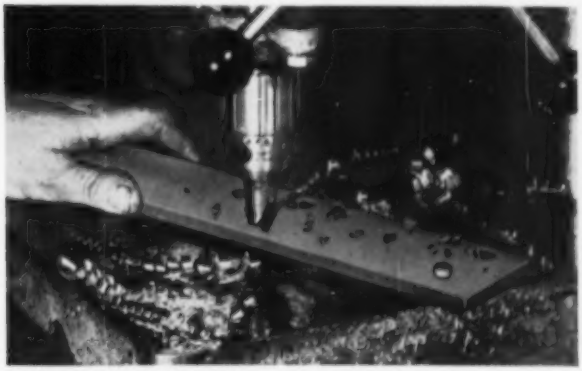
THE TRAILMOBILE SHIFTABLE TANDEM—Truckers often lose time and money in shifting trailer cargo, changing tractors, or cutting payload to meet legal axle-weight requirements. Now, however, they can balance any load in just five minutes by moving the Shiftable Tandem Axle Assembly made by Trailmobile Inc., Cincinnati, Ohio. The axle assembly slides forward or backward, as needed, along a stainless steel rail on four shoes of wrought Everdur. It can move 66 inches and be locked at 3-inch intervals by locking rods through holes in the rail.



EVERDUR CAN TAKE THE LOADS AND SPLASH—One of the shoes of wrought Everdur installed in the Shiftable Tandem frame. An Alemite fitting in center hole and oil grooves provide lubrication. The Everdur shoes carry normal tandem loads of 32,000 pounds day and night, and slide freely under this pressure. Resistance to corrosion is another reason why Everdur was selected, for unlike the trailer's cargo, the Everdur shoes are exposed to road splash of varied mixtures.

Wherever metal must resist corrosion, be strong and tough, and be available in forms easily fabricated, consider Everdur, Anaconda's family of copper-silicon alloys. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. *Reg. U.S. Pat. Off. 5661

HOW WROUGHT EVERDUR CUT MATERIAL COSTS—Trailmobile first tried high-tin bronze castings for the shoes on which the assembly slides. But rejects for porosity and warpage in the thin cast section were a costly problem—and all surfaces had to be finish-machined. The wrought Everdur bar stock suggested by Anaconda's technical experts has surfaces satisfactory as delivered—ready for drilling holes (shown above).



HOW WROUGHT EVERDUR CUT LABOR COSTS—The castings formerly used were not uniform. Hard spots made surface machining difficult and expensive. The entire operation was unnecessary with wrought Everdur bar stock—reducing labor cost by about 50 per cent. (Above) Countersinking holes for screw fastenings.

WROUGHT EVERDUR IS READILY MACHINABLE—Though tough and dense, wrought Everdur is uniform and poses no special problems in machining. Oil grooves are shown being milled in the shoes.

EVERDUR

ANACONDA® COPPER-SILICON ALLOYS

NO SINGLE ABRASIVE

can do ALL blast cleaning jobs BEST

It is a fact that your own requirements as to finish and speed determine the type of abrasive you should use. As an example: for heavy cleaning chilled iron shot or grit is indicated; for less severe cleaning or scale removal annealed iron shot or grit may be used. Controlled T "chilled" and Permabrasive "annealed" shot and grit are engineered for the jobs they are to perform. We'll guarantee that our abrasives will produce a savings over your present abrasive costs or we will give you a check to cover the guaranteed savings.* How can you lose? Now is the time to make a test—now is the time to save on your blast cleaning costs.

*10% in the case of Permabrasive, 15% in the case of Controlled T

WRITE FOR:

- ☐ "A Primer on the Use of Shot and Grit"
- ☐ "It's Triplets" (A Story of Palletizing)
- ☐ "Tired of Making Tests?"

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Nominating Committees for A.S.M. Officers

In accordance with the Constitution of the American Society for Metals, President Adolph O. Schaefer has appointed a nominating committee to select candidates for president (for one year), vice-president (one year), and two trustees (two years). This committee, selected from names submitted by the chapters, consists of:

Chairman: Carl B. Post (Lehigh Valley Chapter), Carpenter Steel Co., Reading, Pa.

Harold J. Roast (Ottawa Valley), 140 Grosvenor Ave., Ottawa, Ont., Canada.

D. J. Wright (Peoria), Caterpillar Tractor Co., Peoria, Ill.

H. E. Flanders (Utah), University of Utah, Salt Lake City, Utah.

James V. Coulter (Golden Gate Chapter), Coulter Steel & Forge Co., Emeryville, Calif.

Oscar T. Marzke (Washington Chapter), Division of Physical Metallurgy, Naval Research Laboratory, Washington 20, D.C.

Arnold L. Rustay (Worcester Chapter), Wyman-Gordon Co., Worcester, Mass.

A. R. Fairchild (Carolinas Chapter), Western Electric Co., Winston-Salem, N.C.

Albert T. Ridinger (Minnesota), Metallurgical Inc., 900 East Hennepin, Minneapolis 14, Minn.

Also in accordance with the constitution, a committee for the nomination of secretary (two years) has also been appointed, consisting of the president and the six immediate past presidents. This committee consists of: A. O. Schaefer, *Chairman;* George A. Roberts, James B. Austin, Ralph L. Wilson, John Chipman, Walter E. Jominy and Arthur E. Focke.

These two committees will meet during the third full week in May. They will welcome suggestions for candidates in accordance with the Constitution, which provides that endorsements of a local executive committee shall be confined to members of its local chapter, but individuals may suggest to the nominating committee any candidates they would like to have in office. Endorsements may be sent in writing to members of either committee.

making stainless steel?

WASTE IS COSTLY!

Waste can mean a lot, especially if you have excessive conditioning costs or high rejection rate.

The addition of Vancoram Grainal Alloys has greatly improved hot-working characteristics of stainless and heat-resisting grades for many producers.

Think what that means—particularly in the higher alloy grades that are prone to develop cracks and other surface defects. Grinding, chipping and scarfing—the loss of good metal can be held to a minimum. You save in rejection and conditioning costs, which result in higher yield and the conservation of scarce alloying elements. And you step up production at the same time.

Why not try this new application of Vancoram Grainal Alloys. Your nearest Vanadium Corporation Sales Office will be glad to help you.

VANCORAM

Producers of alloys, metals and chemicals

VANADIUM CORPORATION OF AMERICA

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Digests of Important Articles

Bismuth Additions to Steel

"Digest of Experiment of Adding Metallic Bismuth to Liquid Steel", by V. S. Bozhko, *Trudy Instituta Chernoi Metalurgii*", Vol. 7, 1953, p. 54-56.

RUSSIAN metallurgists have been attempting to raise the quality of steel and reduce the amount of nonmetallic inclusions by improving melting, deoxidation and casting practice. Reduction of inclusions by the use of inert gases has been tried but was found to be either impractical or too expensive.

It was decided to study the effect of metallic bismuth because:

1. According to the available binary equilibrium diagrams, bismuth is insoluble in iron and in the other elements in steel and should be inert in liquid steel.

2. The specific gravity of bismuth is 9.8 compared to about 7.0 for steel, so it should be easy to add to steel.

3. The vaporization temperature of bismuth is about 1450° C. (2640° F.) and it would vaporize when added to liquid steel. The escape of this vapor might cause nonmetallic impurities to rise to the surface of the liquid steel.

4. Bismuth increases the fluidity of liquid steel and therefore would facilitate the casting of thin or intricate sections.

The effect of additions of granular bismuth was studied both in the laboratory and in commercial practice. The laboratory heats were 7 to 11 lb., and the bismuth was added in the mold. For commercial ingots of 44 to 950 lb. the bismuth was added in the ladle. In 2500-lb. ingots the additions were made on the ladle, mold or feed trumpet. Dense brown fumes were given off when bismuth was added in the mold but only slight fuming was observed with the other two addition methods. However, some fuming occurred during the teeming of ingots from ladles treated with bismuth.

The liquid steel treated with bismuth was more fluid and more active in the mold. The steel retained a mirror surface because the formation of oxide layers was retarded, even in steels containing chromium.

In spite of these phenomena, however, there was no significant effect of bismuth additions on the properties of the final steel bars, and it was impossible to find any trace of residual bismuth in the steel, even with a spectroscope. The amounts of nonmetallic impurities were the same in steels deoxidized in the usual manner with aluminum or ferrotitanium and those given an additional treatment with bismuth. There was no difference in the tensile and impact strengths in either the longitudinal or transverse directions.

A. G. GUY

New Gas Turbine Alloy

Digest of "Engineering Requirements for Jet Engine Materials", by D. K. Hanink, F. J. Webbere and A. L. Boegehold, presented at Society of Automotive Engineers meeting, January 1955.

A NEW nickel-base high-temperature alloy is described which has both higher strength and lower content of strategic alloying elements than other turbine-blade alloys. Cast blades made from this alloy, called GMR-235, have outlasted all competitive alloys in turbo-supercharger service at 1500° F. In production aircraft gas-turbine engines, cast blades have lasted for as long as 800 hr. Stress-rupture properties are shown in Fig. 1.

The composition of GMR-235 is 0.10 to 0.20% C, 0.25% max. Mn, 0.60% max. Si, 14 to 17% Cr, 8 to 12% Fe, 4.5 to 6.0% Mo, 2.5 to 3.5%

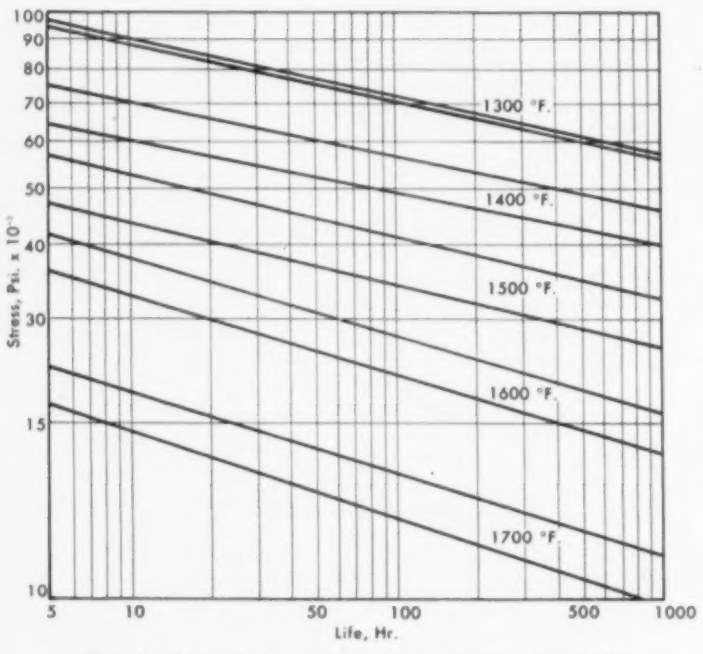


Fig. 1 – Stress-Rupture Properties of As-Cast GMR-235

Case No. 107

Harris Steel Co. Reports:

- 4 Years' Trouble-Free Service
- Constant 24-Hour Operation
- Careful Control of Quality

Michael J. Giordano inspects test burner on one of twin Kemp Atmos Gas Producers.

Bright Annealing Furnaces Use Kemp Atmos Gas Generators to Supply Controlled Atmosphere of Uniform High Quality

Bright annealed steel is produced by Harris Steel Company, Kearny, New Jersey, with the help of two Kemp Model 6-MR Atmos Gas Producers. These two Kemp Generators burn city gas, to supply twelve furnace bases with purified controlled atmosphere.

Treating gas 24 hours a day, seven days a week, each Kemp unit produces 6,000 cfh of gas . . . enough to meet the needs of annealing 4,000 to 5,000 tons of steel per month.

User Reports Complete Satisfaction

Mr. Harry Vane, Plant Superintendent, reports "These Kemp units have been in constant service for 4 years without a bit of trouble. The only maintenance needed has been ordinary routine. Because of the constant purity and qualitative analysis of the gas the Kemp Generators produce, we have been able to secure constant control of color, temper and quality of our output."

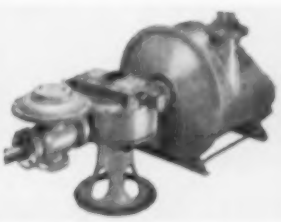
Kemp Can Help You, Too

If efficient, carefully-controlled supply of protective atmosphere gas can help you solve production problems, it will pay you to call in a Kemp Engineer for a detailed discussion of your needs. No obligation, of course.

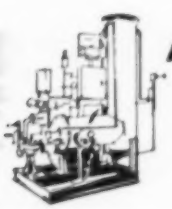
Write to: C. M. KEMP MFG. CO.,
405 E. Oliver Street, Baltimore 2, Maryland.

General view of Harris Steel Co. Bright Annealing Department, showing several of the 12 annealing furnaces supplied with Atmos Gas by Kemp Model 6-MR Generators.

This Kemp industrial carburetor—the heart of every Kemp installation—assures the desired analysis of protective atmosphere gas under any demand without waste . . . without frequent adjustments.



KEMP OF BALTIMORE



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IMMERSION MELTING POTS
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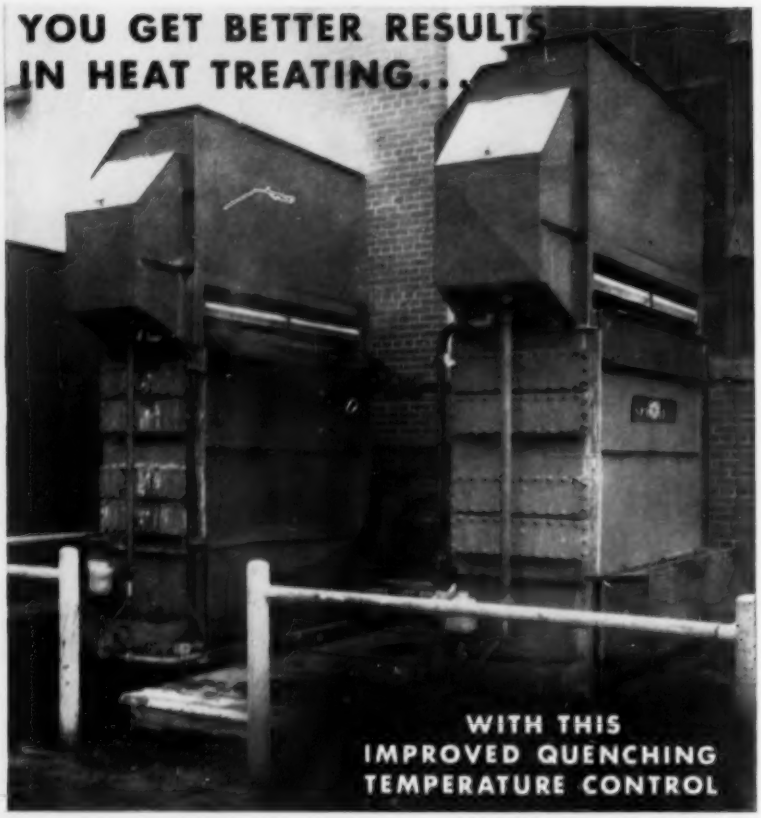


Photograph . . Permission of Ford Motor Co.

● Use the **NIAGARA AERO HEAT EXCHANGER** to control the temperature of your quench bath and you remove the heat at its rate of input, always quenching at the exact temperature that will give your product the best physical properties. You get uniform results throughout the day's production, prevent losses, avoid rejections, increase your heat treating capacity.

The Niagara Aero Heat Exchanger transfers the heat to atmospheric air by evaporative cooling. It extends your quenching capacity without using extra water. It pays for itself with water savings.

In the installation illustrated the quench is caustic soda. Water also is accurately cooled and the system is easily kept clean. With an oil quench an extra advantage is to prevent flash fires.

You can cool and hold accurately the temperature of all fluids, air, gases, water, oils, solutions, chemicals for processes and coolants for mechanical and electrical equipment. With the Niagara Aero Heat Exchanger you have closed system cooling, free from dirt and scale.

For further information write for Bulletin No. 120

NIAGARA BLOWER COMPANY

Dept. MP, 405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of United States and Canada

Turbine Alloy . . .

Al, 1.5 to 2.5% Ti, 0.025 to 0.100% B and the remainder nickel. The relatively low content of strategic alloying elements is indicated by its low rating in comparison with other gas-turbine alloys:

Alloy	Strategic Rating	Stress-Rupture*
S 816	2562	24,000
HS 36	2527	29,000
HS 31	2441	28,400
Nimonic 90	896	28,000
Inconel "X"	849	28,000
Nimonic 80	364	24,000
GMR-235	306	38,000

The high strength at elevated temperatures is obtained by the relatively high titanium, aluminum and boron contents. Strength increases with boron content up to about 0.25% but the ductility decreases when boron is greater than 0.10%. The strengthening is apparently due to the formation of a complex boride phase at the grain boundaries.

The best combination of high-temperature strength and ductility is obtained when the total content of aluminum plus titanium is between 5.0 and 6.5% as shown in Fig. 2. If

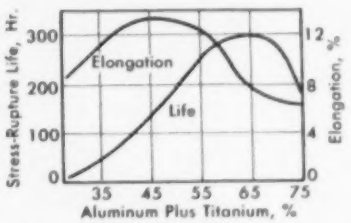


Fig. 2 – Effect of Combined Aluminum and Titanium Content on Strength and Ductility of GMR-235

more than 4% Al is used the ductility decreases. With 4% Al, 2% Ti gives the best ductility.

Strength is increased by either a solution anneal or by an aging treatment. As-cast samples aged at 1800° F. for 5 hr. have the best high-temperature properties. A solution treatment of 1 hr. at 2100° F. followed by either air cooling or water quenching nearly doubles the stress-rupture life of as-cast samples at 1600° F. and 28,000 psi. Aging of

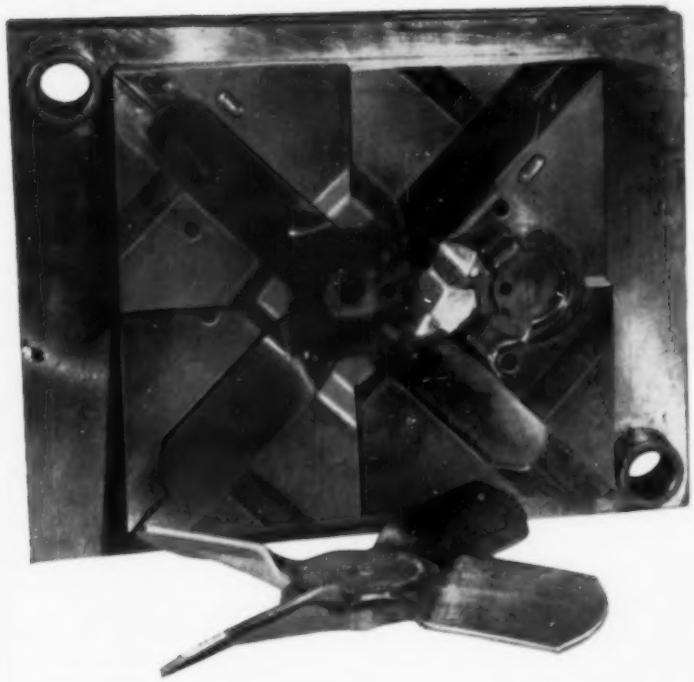
*Stress to produce rupture in 100 hr. at 1500° F.

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation



They're Using Cr-Mo-W Die for Fan Hub Part

Economy and long service life were the chief reasons that led Production Die Casting Company, Houston, Texas, to select Bethlehem Cr-Mo-W tool steel for the manufacture of this hub for an attic fan.

The two-part die, with Cr-Mo-W (chrome-moly-tungsten) used for both sections, is approximately 16 in. x 18 in. The part is cast of aluminum alloy, at 1250 F. Engineers at Production Die Casting Company say, "Performance of this die has been excellent. It has provided long, satisfactory service life."

Cr-Mo-W is an ideal tool steel for applications involving drastic changes in temperature, where heat-checking and shock are a problem.

Cr-Mo-W is our general-purpose type of hot-work tool steel. It hardens in air, and has good red-hardness and good machinability. Your Bethlehem distributor carries it in stock, in sizes to meet your needs.

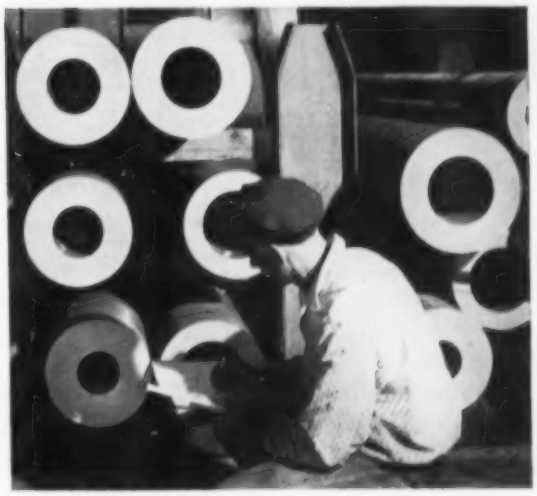
BETHLEHEM TOOL STEEL ENGINEER SAYS:

Smooth Finish in Grinding Improves Tool Life

A smooth ground finish on tools with a cutting edge is essential to good tool life. This was proved recently in an application involving the use of our Lehigh H tool steel in a rotary slitting knife.

In normal operation on hot-rolled strip these knives cut about 8000 tons per edge on the original grind. But after being reground in the mill, production dropped to about 3000 tons per edge. Investigation revealed that the reground finish was rough and coarse, which meant in effect that the cutting edges were already dulled before being used in service. When the same knives were properly reground with a smooth finish, production again averaged 8000 tons per edge.

Generally, a smooth ground finish of from 10 to 15 micro-inches on a profilometer is satisfactory for good cutting-edge performance. In the event that coarser finishes are used, you may find production decreased.



"HOLLOW-BAR" IN TWO TYPES

Bethlehem Hollow-Bar Tool Steel is now made in two types: BTR (Bethlehem Tool Room, oil-hardening), and Lehigh H (high-carbon, high-chrome). Hollow-Bar is made by a high-speed trepanning process, by which hammer-forged or hot-rolled bars are cored out, then rough-turned on the outside. Hollow-Bar is an ideal time-saver on hardened bushings, ring dies, draw-rings and the like because the steel can be put right to work. There's no need to wait for forged rings or discs.

When compressive strength is important . . . look to KENNAMETAL*

The high compressive strength of Kennametal tungsten carbide compositions offers an unusual physical property to designers in that it is higher than that found in virtually all melted, cast or forged metals and alloys. It is as high as 800,000 psi.

In addition, Kennametal offers high hardness (85.0 to 93.0 Rockwell A); an extremely high Young's Modulus of Elasticity (as much as 94,300,000 psi); exceptional wear properties (as high as 100 to 1 as compared with steel); plus high impact strength and unusually high resistance to abrasion.

Where retention of compressive strength at high temperatures presents a problem, Kentanium* may be the solution. Kentanium titanium carbide compositions combine high compressive strength and resistance to oxidation and thermal shock at temperatures of 1800°F. and above.

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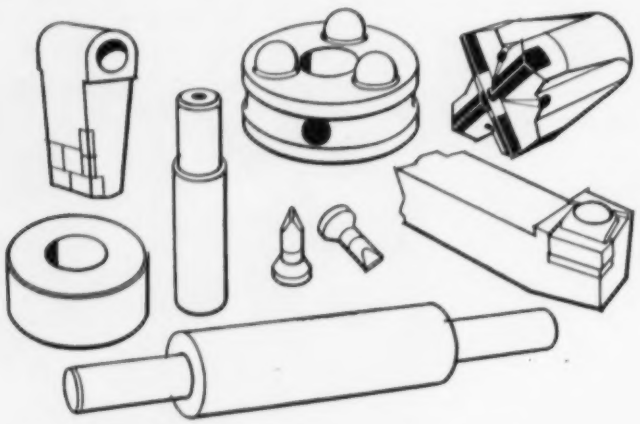

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Turbine Alloy . . .

the solution-treated material at a temperature of 1800° F. does not improve its properties.

In addition to the stress-rupture evaluation, this paper includes data from thermal shock tests and high-temperature fatigue and internal damping measurements. Alloy GMR-235 appears to meet all requirements for gas-turbine blades.

H. J. ROAST

Atmospheric Corrosion of Aluminum

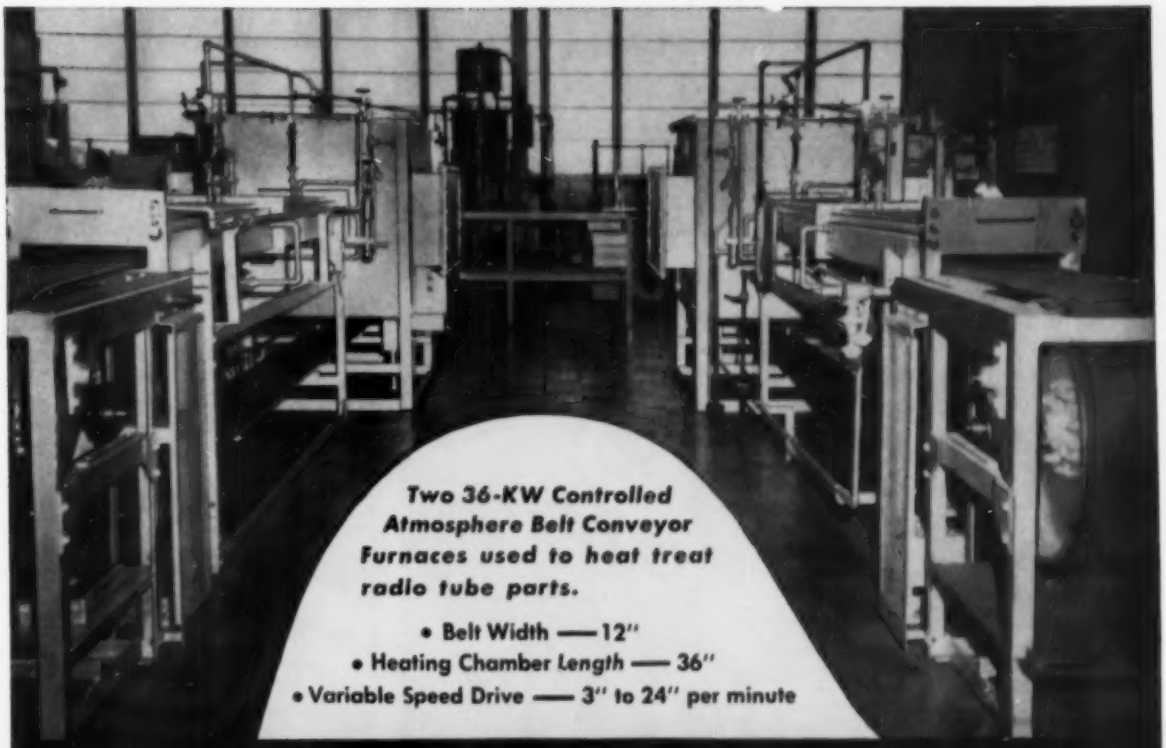
Digest of "Atmospheric Corrosion of Aluminum Alloys in a Large Chemical Factory and Their Protection by Painting", by W. D. Clark, *Journal* of the Institute of Metals, Vol. 84, October 1955, p. 33-41.

ALTHOUGH structural steel is less expensive than aluminum the cost of protecting steel against corrosion is so high that aluminum might be more economical for structural applications if it required less painting. To obtain data on this question the Imperial Chemical Industries, Ltd. of Durham, England conducted atmospheric corrosion tests at four sites for 47 months.

The aluminum alloys tested most extensively were those containing 5 to 7% Mg (No. 6 or 7), or 0.6% Mn, 0.6% Mg and about 1% Si (No. 10), and the same with about 4% Cu (No. 15). Pure aluminum and 0.15% carbon steel were also tested. No clad specimens were tested because the results were to be applied to welded structures. Both extruded bars and sheets were included.

Some of the specimens were anodized and others were treated with chromate before exposure or painting. The protective paints investigated included six primers (oils with various pigments such as zinc chromate, lead chromate alone or with iron oxide, iron oxide alone and portland cement), and 11 paints that included tar plus coal in naphtha, and various oils or resins with iron oxide, titania, or flake aluminum as pigments. The primers and paints were applied by hand brushing.

All specimens were exposed to the weather at 45° from the vertical



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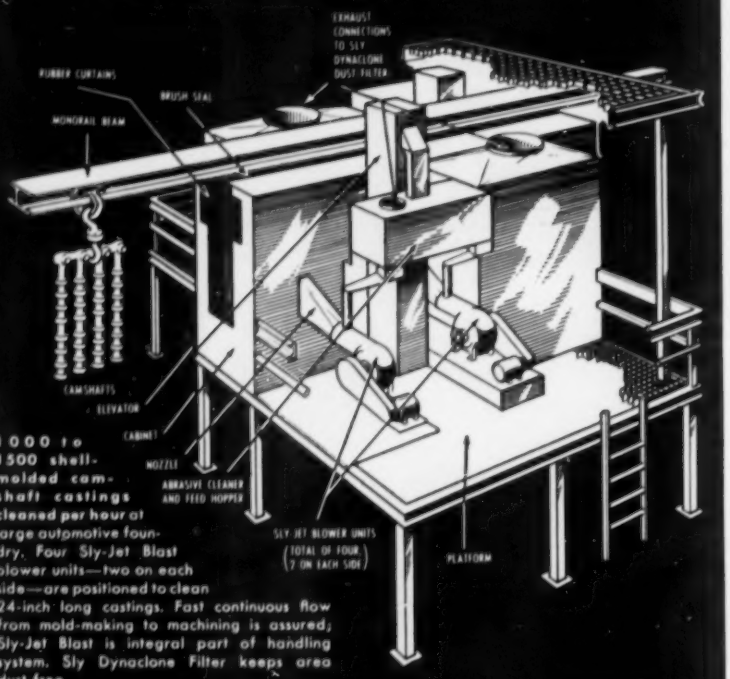

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Corrosion . . .

position, and facing south, between 9 in. and 4 ft. from the ground. The four exposure sites were:

1. A railway yard occasionally dampened by clean water spray.
2. Near a quenching tower for coke ovens.
3. Adjacent to ammonium sulphate and sulphide plants.
4. Near a nitric acid plant with steam and spray nearby.

After exposure the specimens were graded by observers on their general appearance. Some of the gradings were checked by a second appraisal. The grades were expressed by numbers between 1 and 10; the final value reported for each sample was the average of all the observer's grades on duplicate specimens.

Steel specimens were tested at the four sites for only 16 months since all unpainted samples were badly corroded in that time. The corrosion of bare steel was most rapid at site 3, where the average penetration rate was 12.4 mils per year. Site 3 also gave the lowest grades for painted steel. Site 4 was best for bare steel, but next to the worst for painted. All the painted steel specimens were finished with tar paint. The best corrosion resistance was obtained by wire brushing and application of a lead chromate or red iron oxide primer before painting with tar. Shot blasting and the cement primer were inferior. At site 2 corrosion was slower than at the other sites for the steel specimens painted in the laboratory. When steel was first weathered at site 2 and then cleaned and painted, corrosion was very rapid.

The visual grading of bare aluminum alloy specimens after exposure resulted in the lowest marks at all sites for alloy No. 15 containing copper. This alloy also showed the greatest drop in tensile strength from corrosion. Corrosion of this alloy was intercrystalline and produced exfoliation or blistering. At sites 3 and 4 pure aluminum appeared to resist corrosion better than the alloys but this was not supported by tensile tests. Alloy No. 10 maintained its strength best after exposure in spite of a tendency toward intercrystalline attack. The lower surfaces of specimens of all the alloys were more severely pitted than the upper

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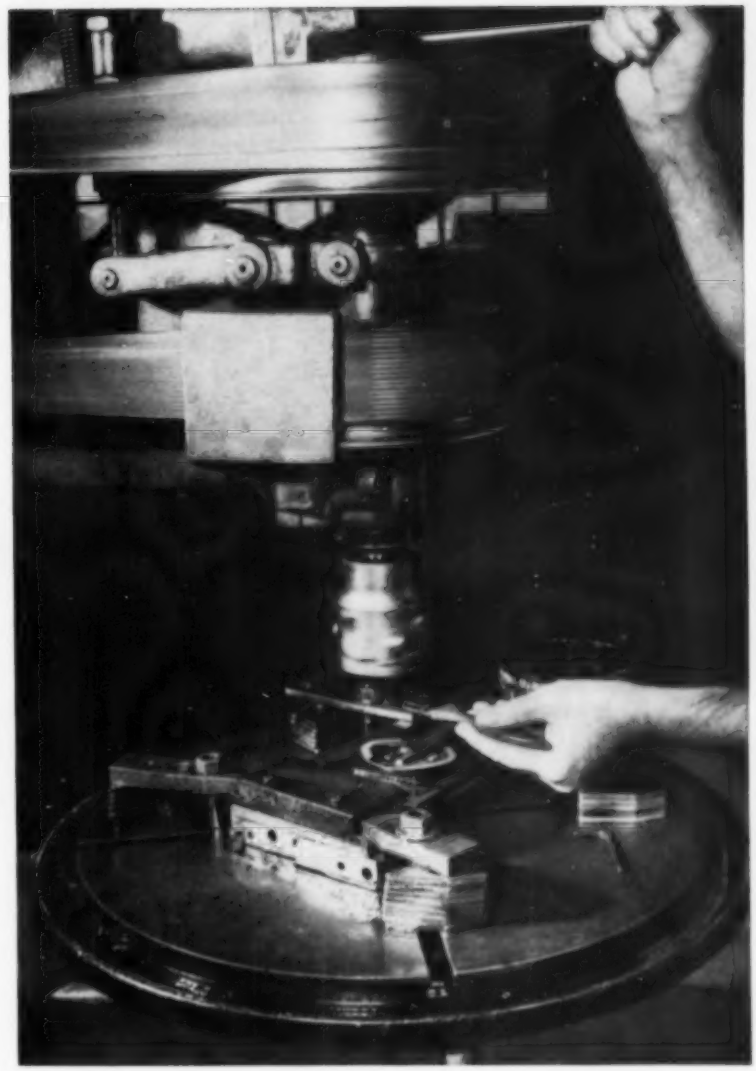

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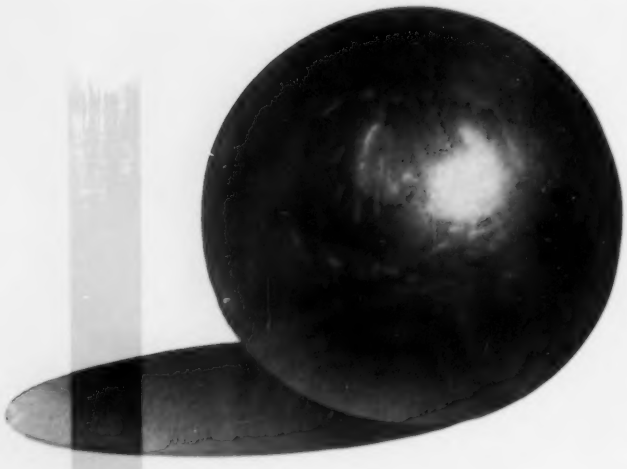

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Corrosion . . .

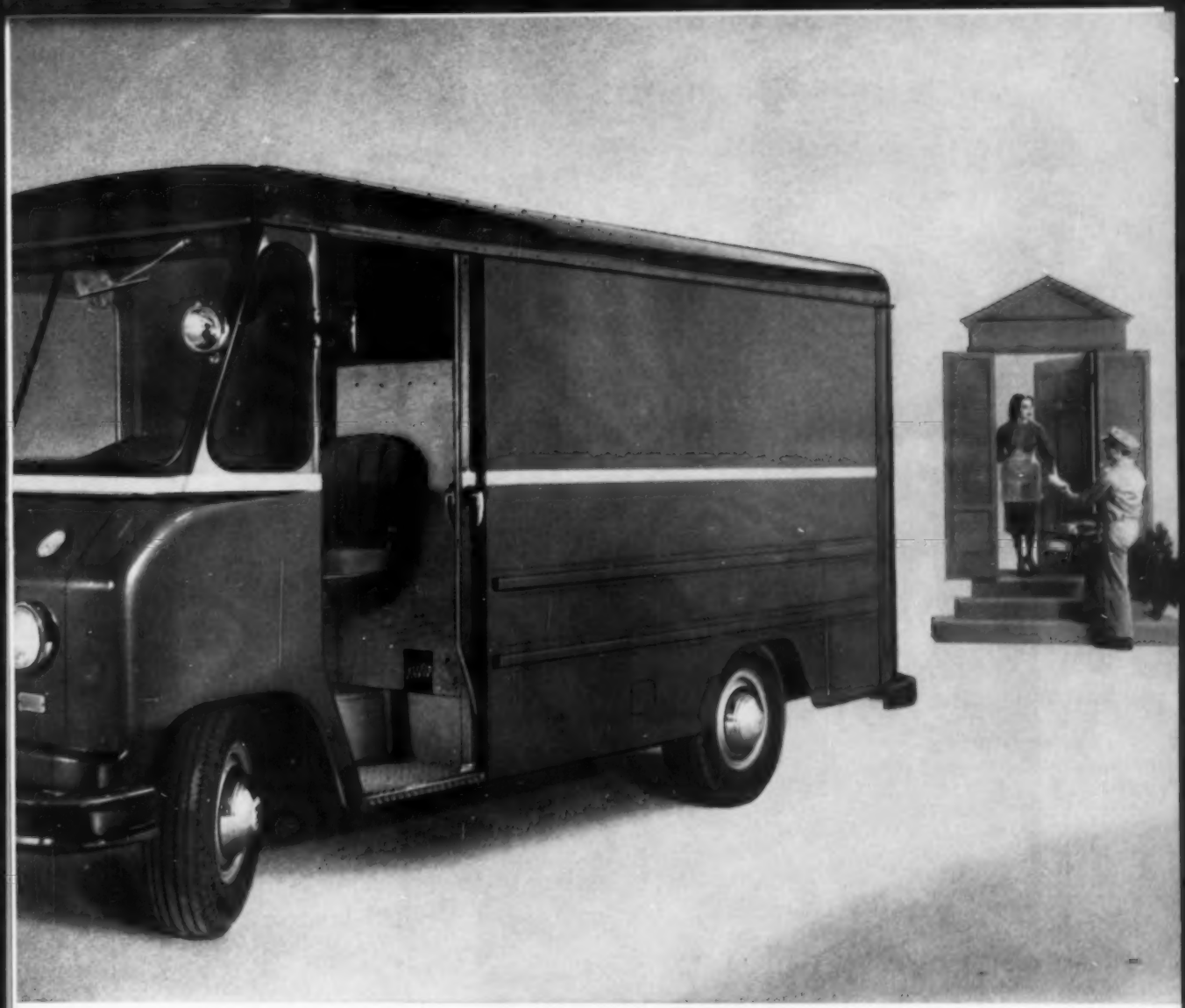
surfaces at all sites except No. 2. Otherwise little difference between alloys or sites is found in data for the bare aluminum alloys. Chromate treatment without paint did not affect the corrosion although it stained the surface yellow.

Results for the aluminum alloys painted with tar paint showed that zinc chromate with micaceous iron oxide in linseed oil was the best primer, and that pretreatment with an application of chromic and sulphuric acids was helpful. With these treatments and tar paint, pure aluminum and the Al-Mg alloys were rated 80 to 82, the Al-Mn-Mg-Si alloy 72 to 78, and the copper-bearing alloy 42 to 50. There was little difference between the various sites. Attack was more severe on the under sides. After 47 months these specimens were in better condition than the painted steel after 16 months.

The range of variation caused by the use of different paints was not large but the best ratings were attained with iron oxide, especially the micaceous variety in "linseed-tung stand-oil". Pretreatment was definitely worth while, the best being anodizing or chromate dipping. Pretreatment followed by a cheap paint gave better results than the use of a more expensive paint without it. The application of two finish coats (three including the primer) gave thicker coatings and better results with iron oxide paint but not with titania paint. The micaceous iron oxide paint gave an exceptionally thick coating which may be the reason for the superior results with it. The differences in results between the finish paints were considered insignificant. A good pretreatment was most important. Zinc chromate was preferred among the primers; the carrier was unimportant.

Some of the painted specimens of copper-bearing aluminum alloy which had corroded appreciably in 16 months were locally cleaned by wire-brushing, primed, coated with tar paint, and retested. After 31 months additional exposure, they were in better condition than specimens exposed 47 months without an intermediate repair.

At sites 1, 3 and 4 all specimens showed more localized and deeper pitting on the under sides than on



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Corrosion . . .

the upper. Perhaps this was due to promotion of pitting by adhering dust but no reason was found for the absence of the effect at site 2 since upper surfaces there became very dirty. It is common to find the inner side of aluminum sheathing close to a wall corroding faster than the outer side, unless the inside atmosphere is clean and dry.

At site 4 most of the specimens resisted corrosion better than at the other sites; the worst attack occurred with most types at site 3.

Two instances of good outdoor service of an aluminum alloy in sheet form are described in detail. An unpainted roof and sides on a compressor house have shown only a gritty white patina in five years except for slight corrosion where parts of the sides are only a few inches from a brick wall. Ventilators of the same alloy on the roof of a gas plant became dirty and acquired a gray patina in eight months. They were brushed, primed and painted with tar. Three years later there was but little deterioration; painted steel would have lasted only a year or two at the same location.

G. F. Comstock

Inhibition of Grain Growth

Digest of "The Effect of Aluminum Nitride Precipitation in Relation to Grain Growth in Steels", by A. B. Chatterjea and B. R. Nijhawan, presented at the annual meeting of the Indian Institute of Metals in January 1955, 25 p.

Although vanadium and sulphur also restrict grain coarsening in steel, the most commonly used grain refining element is aluminum. From the various proposed theories that aluminum, alumina or aluminum nitride is directly responsible for the inhibition of austenitic grain growth, the explanation based on the nitride seems preferable.

To obtain confirmatory experimental evidence, the grain sizes of 12 steels containing 0.22 to 0.44% C, 0.55 to 1.24% Mn, up to 0.28% Si, up to 0.2% S, 0.002 to 0.009% acid-soluble N, and from traces to 1.2% Al were investigated. Most of

the steels were melted in a 75-lb. induction furnace but two were openhearth steels. They were normalized in bar form and pack-carburized before determination of the grain size. The critical points of 0.4% carbon steels were raised appreciably by 0.239% Al or more.

The grain size of the steels to which no aluminum was added coarsened gradually above 1560° F. Those with 0.02 to 0.07% aluminum did not coarsen appreciably up to 1740° F., but at 1830° F. or higher became much coarser. The coarsening temperature rose with the residual aluminum content of the steel up to about 0.1%, at a rate somewhat similar to that of the solution temperature of aluminum nitride. With higher aluminum, however, the grain-coarsening temperature decreased. The alumina contents of all these steels (except the one with 1.2% Al) were practically the same.

Other publications are quoted to explain how the theory that aluminum nitride is responsible for inhibiting grain growth in aluminum-treated steels accounts for these observations. There is more nitrogen in the insoluble residue from finer-grained steels. Aluminum nitride dissolves in the steel and loses its effectiveness at a high temperature, thus explaining the coarsening, and the solution temperature has been shown to correspond roughly with the coarsening temperature. Its solution requires a higher temperature when the aluminum content is higher, thus explaining why the coarsening temperature rose with the aluminum content. The decrease in coarsening temperature with excessive aluminum could be explained if the particle size or distribution of the nitride were different in the very high aluminum steels.

Some steels of different aluminum contents were soaked in purified nitrogen for 24 hr. at 1920° F., and the nitrogen absorption was greater with higher aluminum. With 1.2% Al, the nitride was formed in sufficient amount to appear plainly as dark needles in an unetched photomicrograph at 940 × magnification, especially near the exposed surface of the sample. The identity of the needles was checked by comparison with a specimen heated in contact with potassium cyanide. The needles are also identified as aluminum nitride by X-ray diffraction. Some spe-

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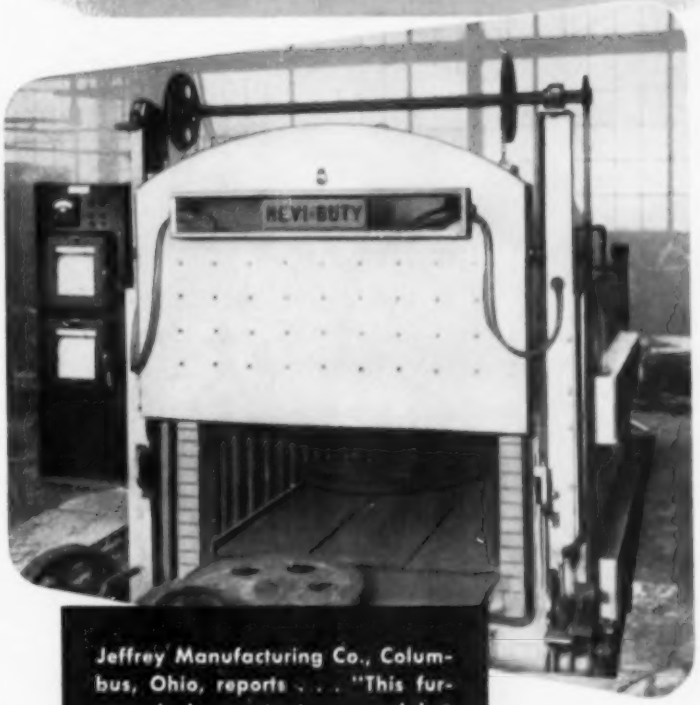

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Grain Growth . . .

cial melts of 0.4% C steels with 1% Al were treated with cyanide or cyanamide. In one containing 0.02% soluble nitrogen, "very small" needles were found after heating 8 hr. at 1710° F., and "readily visible" needles after 2 hr. at 2190° F.

Microscopic examination of a series of steels containing from zero to 2.34% Al, soaked 28 hr. in nitrogen at 1920° F., revealed no needles even at 2000 × magnification in the steels with less than 0.05% Al. With more aluminum, progressively more and larger needles were found. It was assumed that in steels containing 0.02 to 0.05% Al, submicroscopic nitride needles are formed during austenitizing which are most effective for preventing grain growth. When such a steel is austenitized at temperatures above 1830° F. the nitride dissolves and allows the grains to coarsen. This solution does not occur up to 2100° F. in steel containing 1.2% Al, presumably because the solution temperature of aluminum nitride in it is higher.

The reason why steels containing over 0.1% Al have a lower grain-coarsening temperature than those with less aluminum is probably because the nitride is agglomerated into particles too coarse for effective grain-growth inhibition. Supporting evidence is presented in a micrograph of segregated and rounded needles in a 1.2% Al steel heated at 2190° F. Coalescence probably occurs at lower temperatures in steels containing 0.1 to 1.0% Al.

Maximum grain-growth inhibition and enchancement of toughness occur with about 0.018 to 0.05% Al, and are probably caused by the presence of aluminum nitride.

In a discussion by R. L. Rickett and W. C. Leslie, it is suggested that the grain-growth-inhibiting aluminum nitride particles are probably not formed during austenitizing, but existed earlier in the steel. They also believe that the lower grain-coarsening temperature of higher-aluminum steels is best accounted for by the low solubility of aluminum nitride in such steel which causes nitride to precipitate at an early stage of the mill process when the temperature of the steel is so high that comparatively few coarse crystals are formed.

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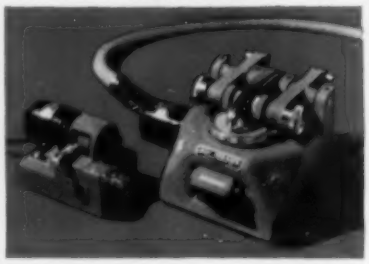

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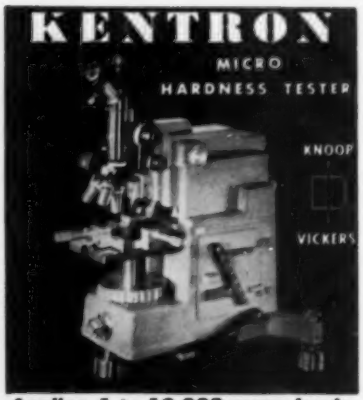

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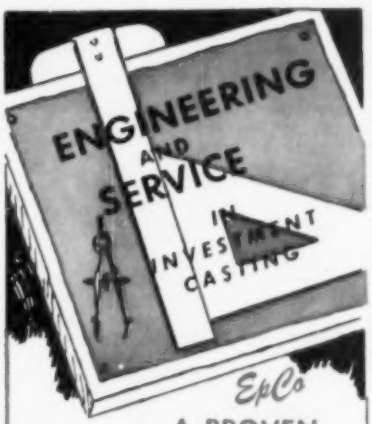

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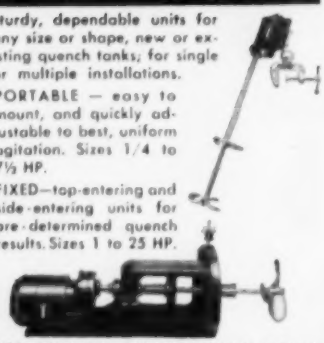

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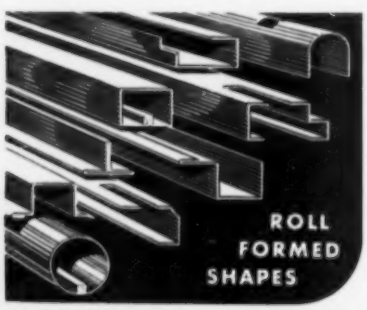

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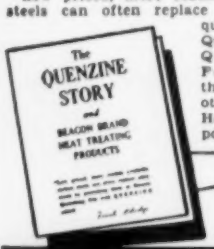

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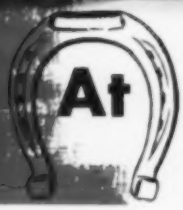

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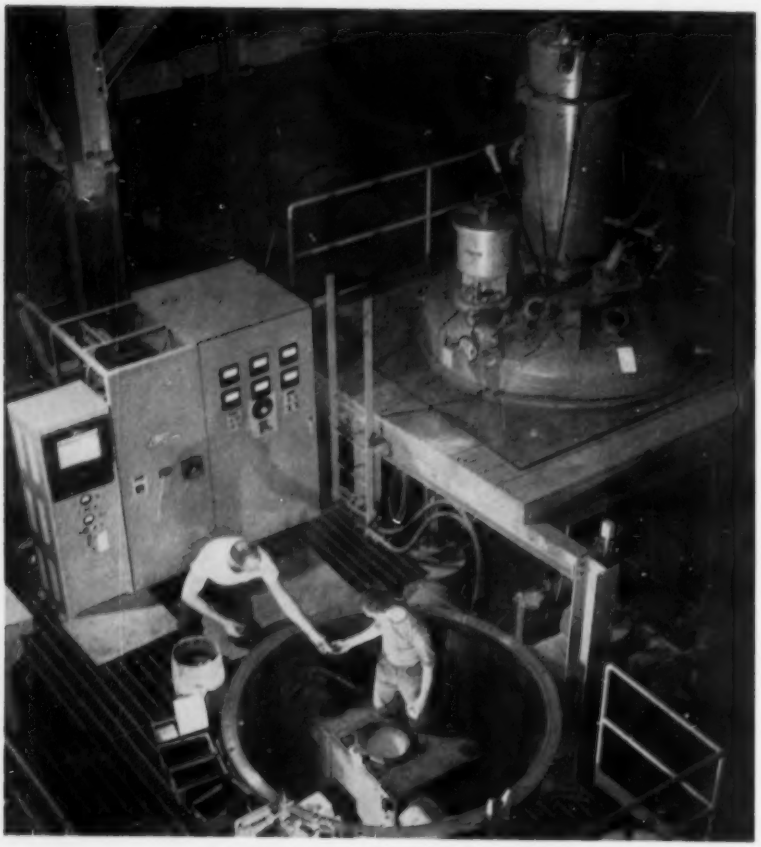

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Ingot Heat Conservation

Digest of "Ingot Heat Conservation — the Cooling of Rimming-Steel Ingots Between Teeming and Stripping", by M. D. Ashton, R. F. Perkins and L. H. W. Savage, *Journal* of the Iron and Steel Institute, Vol. 181, December 1955, p. 303-312.

A METHOD is described of reducing fuel consumption in soaking pits, increasing pit availability and increasing mold life by stripping and charging all ingots in the hottest possible condition compatible with safe handling. The investigation was made with 8 and 15-ton rimmed steel ingots.

The time from start of teeming to ingot stripping, and mold temperatures are the most significant factors that influence the heat loss from ingots. If the ingots are held in the molds for a minimum possible time, heating times are short, soaking pits are more available and mold life should be longer. Increase of mold temperatures causes a decrease in the rate of heat loss. The time from end of teeming to stripping a heat of ingots is usually established by estimating the time necessary for the ingots to solidify and adding a safety factor to allow for the possibility that the last ingot to be poured may be stripped first.

Ingots with a long track time will have their centers cooled below rolling temperatures when charged into a soaking pit. Prolonged heating times are necessary to restore them to rolling temperature.

At the time of tapping, the heat content of steel is about 4½ therms per ton in excess of that required at the rolling mill. Under the most favorable conditions ingots are stripped after they have lost about 4 therms per ton. An additional therm of heat is lost during the 10 to 20 min. required for transferring into the soaking pits. Such ingots will be charged into the pits with an average heat content about that required for rolling, and only sufficient time will be necessary in the pits for temperature equalization. Other ingots will have cooled below the rolling temperature and will require longer heating times because of the inefficiency of soaking pits as reheaters.

Since the rate of solidification of steel decreases with an increase of mold temperature, empirically fixed

What are your refractory castable problems ?

- High Temperatures?
- Abrasion and Erosion?
- Slag Attack?
- Overhead Applications?
- Insulating Properties Required?

B&W makes a wide range of specialized refractory castables. Whatever your problem, you will find helpful data in B&W Bulletin R-35. Send for your copy today.

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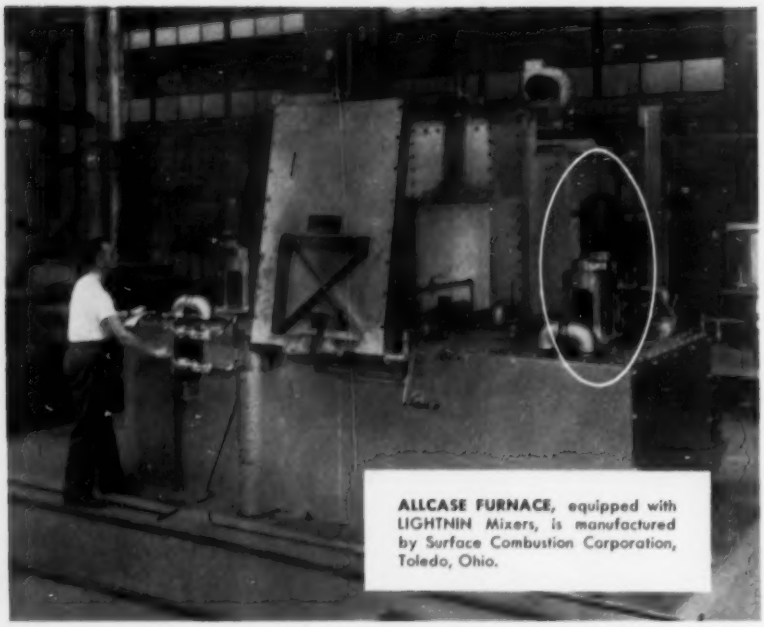


ALLCASE FURNACE, equipped with LIGHTNIN Mixers, is manufactured by Surface Combustion Corporation, Toledo, Ohio.

How Surface Combustion Corp. insures uniform quenching

Looking for better quench results?

Tests show you can increase hardness depth and dimensional stability, reduce retreating and rejects, by using controlled turbulence in the quench bath.

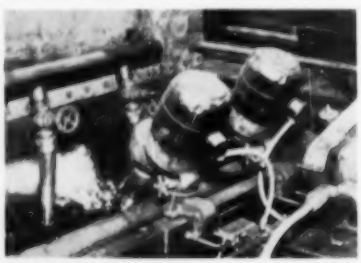
Surface Combustion Corporation, for example, often provides LIGHTNIN Mixers as integral equipment with high-efficiency heat treating furnaces. This results in better quenching, because:

1. You get a much higher rate of quenchant flow with LIGHTNIN Mixers than with other methods using comparable power input. Uniform turbulence wipes and wets every surface of the part being quenched. All surfaces cool at the same rapid rate, so hardness is uniform all over the part.

2. You can answer special quenching needs with standard LIGHTNIN Mixers. You can get the exact balance of turbulence and flow for best results, thanks to unique application data developed in the field and at Mixco.

You can get LIGHTNIN Mixers for any type of immersion quenching, martempering, austempering; for use with any quenchant; in new or existing tanks of any size or shape; for parts as small as a lock washer, as big as a 105-mm gun barrel. Every LIGHTNIN is guaranteed, unconditionally, to do the job for which it is recommended.

If you've a hunch that controlled turbulence can improve *your* quench results, we'd like to help. For details, just write, briefly describing the quench operation you have in mind.



OIL FLOWS RAPIDLY around parts in this quench tank, for quick, uniform heat extraction. Two portable propeller-type LIGHTNIN Mixers provide violent agitation in quench zone.

Lightnin® *Mixers*

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 171-d Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.

Ingot Heat . . .

teeming-to-stripping times are based on safe times for the hottest molds used. Ingots are stripped later than necessary when cold molds are used. Such a practice results in longer heating times, increased fuel consumption and decreased pit availability.

If the gas is turned on full immediately after a heat of hot ingots is charged into a pit, ingots may be withdrawn for rolling when their centers have not fully solidified. Blistered rolled products will result. This could be remedied by soaking the ingots in the pits with the fuel input reduced. Stripping times should be reduced to a minimum so that ingots can be charged to a soaking pit in such a condition that no fuel would be required other than the minimum necessary to offset heat loss from the pit structure.

J. M. H.

Self-Fluxing Brazing Alloys

Digest of "Lithium Additions to Brazing Alloys", by N. Bredzs and D. Canonico, *Welding Journal*, Vol. 34, November 1955, p. 535s-543s.

BRAZING has been done at high temperature in reducing atmospheres without the use of flux and at low temperatures with fluxes. Fluxes complicate the operation and are sometimes trapped in the joint. The present need for complex brazed assemblies in atomic energy work has encouraged studies of alloys that will make brazed joints without flux. They should be suitable for use with stainless steel.

In an effort to produce such an alloy, small additions of metal that are powerful oxidizers were added to silver. About 1% of each of the following was alloyed with silver: Ca, Mg, Al, Be, Si, Ni, Sn, Zn, Cu, Cd, Ba and Li. The alloys were melted on top of a flat mild steel surface by induction heating, usually in an atmosphere of dry helium. Cadmium, magnesium and aluminum reduced the wetting ability of silver. Lithium and barium increased the wetting tendency and the others had little or no effect. Change in drop diameter was used to show the differences.

NICHROME* retort in a carburizing furnace gives 30,000 HOURS SERVICE!

Nichrome retort in the commercial heat-treating department of Stanley P. Rockwell Company, Hartford, Conn. This retort was used in a 30" x 45" Vertical Carburizer†, and served them well for over 30,000 hours. Among the remarkable features of the performance of this Nichrome retort: Temperatures ran between 1700-1750°F., with an oxidizing atmosphere outside, and a carburizing atmosphere inside. Also the retort was subjected to tremendous thermal shock several times each day, by taking on cold work loads in tonnage or near-tonnage lots.

Engineers whose business it is to specify heat-treating equipment have learned — most of them — that the first cost is by no means the important cost. That's why so many of them now specify only Nichrome.

For it's a matter of simple arithmetic in plant after plant where Nichrome retorts, muffles, and other heat-treating equipment pile up outstanding records like the one above, to find that the cost *per heat hour* of long-lasting Nichrome is well below any other alloy that might tempt you by a somewhat lower initial price.

Driver-Harris engineers have priceless experience, too, in *designing* special long life heat-treating equipment for any purpose you have in mind.

Call on them soon with your "hottest" problem, won't you?

*T. M. Reg. U. S. Pat. Off.

†Made by American Gas Furnace Co., Elizabeth, N. J.

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Brazing Alloys . . .

The low melting points of barium and lithium oxides when combined with iron oxide were thought to be the cause of good wetting characteristics of silver alloyed with barium and lithium. Lithium was better than barium.

Tests on drill rod and Type 303 stainless steel showed lithium to be effective on both of these materials. Barium was found to be good on carbon steel only.

Alloys of silver with 1 and 2% Li, and with 28% Cu, 19% Li were melted, degassed and cold rolled to 0.063-in. sheet. These sheets were used as brazing alloys in an atmosphere of 10% H_2 plus 90% N_2 and in pure nitrogen. Tensile tests of the joints showed 40,000 to 50,000 psi. for the silver-lithium alloys. Good joints were also reported for Type 303 stainless steel torch brazed "in oxy-acetylene atmosphere" with 99% Ag, 1% Li alloy. It is presumed that this means brazing in air with an oxy-acetylene torch using a reducing flame, since attempting to use a large quantity of acetylene and oxygen as a protective atmosphere would produce startling results.

The preliminary nature of these tests is indicated by the authors' conclusions:

"1. The experimental results obtained on investigation of wettability of low-carbon steel, drill rod, and 303 stainless steel with the molten 1% Li, 99% Ag alloy fully confirmed the theoretical postulation that lithium is a most suitable metal for developing self-fluxing brazing alloys. This theoretical postulation has been based on comparing some chemical and physical properties of lithium with some other strongly deoxidizing metals.

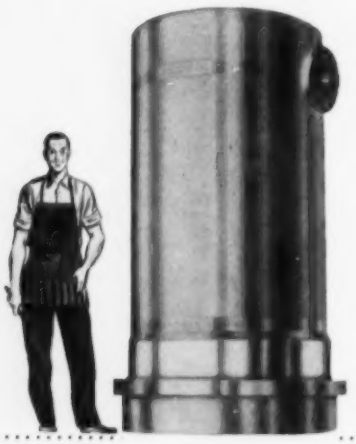
"2. Small additions of lithium to silver result in self-fluxing brazing alloys which are capable of brazing carbon and alloy steels without either flux or reducing gases.

"3. Small additions of lithium considerably lower the wetting contact angle of molten silver on carbon, as well as on stainless steel surfaces, thus promoting extremely good wettability and fluidity of the lithium-bearing silver alloys.

"4. Some preliminary brazing experiments performed in air indicate new possibilities for developing self-fluxing, airproof brazing alloys".

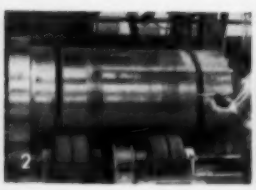
DAN WHITE

Need Large Hydraulic Cylinders?



BUILT TO REQUIRED SIZES AND TOLERANCES BY

TITUSVILLE FORGE



Hydraulic cylinders combining the advantages of thoroughly hot worked steel and clean automatic welding are being furnished by Titusville. Such cylinders insure the user of better physical characteristics (hollow forged shell and flanged sections together with upset forged top or dome sections), freedom from leakage under pressure because of porosity and the complete elimination of costly repairs or rejections. Fabrication is shown in photos above.

1. Hollow forging for shell section being hot worked on mandrel.
2. Hollow and upset forgings assembled for automatic welding.
3. Complete welded cylinder being rough turned in 80" engine lathe.

Let Titusville Forge build your hydraulic cylinders—to your most exacting requirements.

Struthers Wells

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TITUSVILLE FORGE DIVISION

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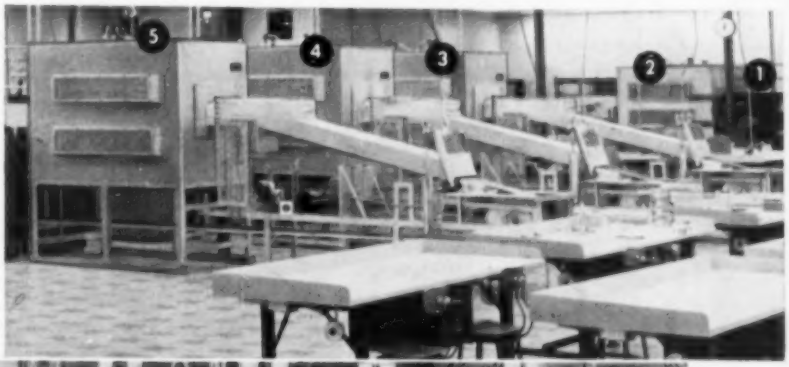
Offices in Principal Cities

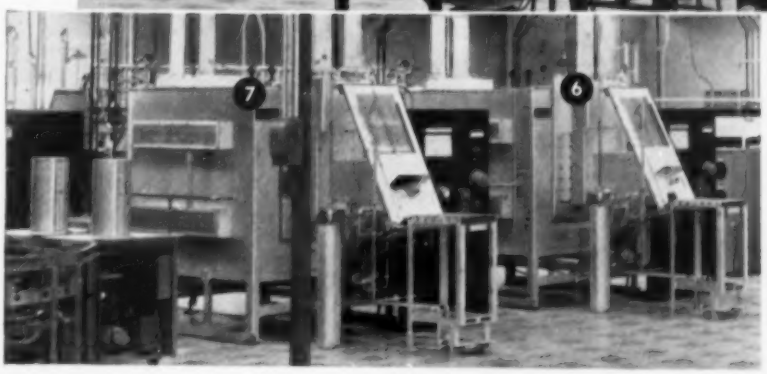
Nondestructive Metallographic Examination

Digest of "Nondestructive Metallography of Plain Carbon Steels", by K. Sachs and J. D. Bunton, *Metallurgia*, Vol. 52, October 1955, p. 205-209.

METALLOGRAPHIC control of the heat treatment of small steel parts is more useful than control by hardness or magnetic tests since it reveals grain size and small traces of undesirable microconstituents. If the microscopic examination is performed on surfaces chemically polished without destroying the sample, the control is more effective and reliable because more and larger

GLOBAR® *Heating Elements in these* 7 SARGEANT & WILBUR *electric furnaces help boost brazing production at* SPERRY-RAND CORPORATION





● This battery of *seven* electric brazing furnaces help Sperry Rand turn out high quality klystron tube components at its Electronics Tube Division in Gainesville, Florida. The five conveyor-type and two pusher-type furnaces were designed and built by Sargeant & Wilbur, Inc., Pawtucket, Rhode Island. All are equipped with GLOBAR® Silicon Carbide Heating Elements.

SILVER AND COPPER BRAZING of klystron tube components on a production basis, in atmospheres continuously purged with dissociated ammonia, calls for uniform, high temperatures, accurately controllable in the furnace chambers. GLOBAR® Silicon Carbide Heating Elements meet every requirement . . . give safe, dependable performance at maximum operating temperatures. In addition, heating with GLOBAR® Heating Elements is clean—free from dirt, noise and fumes.

NAME YOUR PROBLEM—in brazing, annealing, forging, sintering, or any other industrial heating operation—and GLOBAR® engineers will help you solve it completely, economically. Write The Carborundum Company, Dept. MP 87-67, Niagara Falls, New York.

FOR DETAILED INFORMATION on GLOBAR® Silicon Carbide Heating Elements, plus mounting and control recommendations, write for Bulletin "H".

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87-67

Metallography . . .

samples can be prepared for examination for a given cost limit.

Marshall's solution, consisting of 2.5 g. oxalic acid, 1.3 g. hydrogen peroxide and 0.01 g. sulphuric acid in distilled water to a total volume of 100 ml., is recommended for both polishing and etching. Specimens are ground as usual, finishing with fine emery paper of some grade between 0 and 600. They are then immersed in a fresh solution for about 5 min. A wall of plasticine can be used to confine the solution to a small area of a large article. To avoid pitting, the surface to be examined should not be horizontal in the solution, and the solution should be fresh. If the ground surface is too rough, freshness may be lost before even one specimen is prepared. Success has been achieved with 0.08 to 1.13% C steels containing up to 1.4% Cr and 4.5% Ni, and with malleable cast iron and iron containing 2.3% C and 13% Cr. The micrographs are quite clear with no indication of scratches at 200 or 1000 × magnification. This method has been used commercially for such parts as track links, hammer heads, wrenches and screwdrivers and is especially advantageous when the parts are flame hardened. Slight surface decarburization, too small to affect the hardness, can be detected by this method in hardened parts through the presence of a network of troostite in a martensitic structure.

G. F. Comstock

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SENTRY FURNACES employing the positive Sentry Diamond Block atmosphere harden all high speed and air hardening steels including the low-priced molybdenum steels, consistently without spoilage, true to size and completely free from scale or decarburization.

Many users of Sentry equipment are regularly hardening the M-10 and other "difficult" steels with absolutely no "decarb" – producing high quality tools from lower cost steels.

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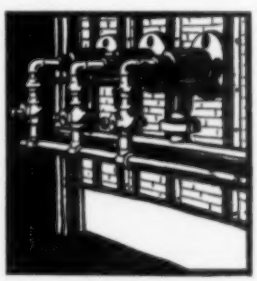
Corrosion by Molten Metal

Digest of a paper entitled "The Behavior of Materials in Aggressive Liquid Metals" by David H. Gurinsky of Brookhaven National Laboratory, read before the American Institute of Mining, Metallurgical and Petroleum Engineers, Feb. 20, 1956.

Corrosion of metal is usually subconsciously defined as oxidation by moisture at atmospheric temperatures. Those engaged in high-temperature work have extended the meaning to include chemical reaction between solid surfaces and hot gases – usually with their oxygen, free or combined. In nuclear metallurgy the term also includes deleterious action by molten metals, and this ordinarily is caused by solution of the solid container into the liquid contained.

The last-mentioned problem was met some years ago when A. J. Nerad and his associates at General Electric Co. were studying the so-called mercury boiler. It will be recalled that this was intended to use liquid mercury rather than water or superheated steam to transfer heat from a combustion chamber to a prime mover. Early experiments showed that the solubility of iron in mercury just below its boiling point in the high-pressure mercury boiler (565° C. or 1050° F.) was vanishingly low (on the order of 0.36 part per million). Consequently no trouble with "corrosion" or wastage of the container (boiler) was anticipated. However, the temperature coefficient of solubility was high; when this



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with EASY-FLO and SIL-FOS

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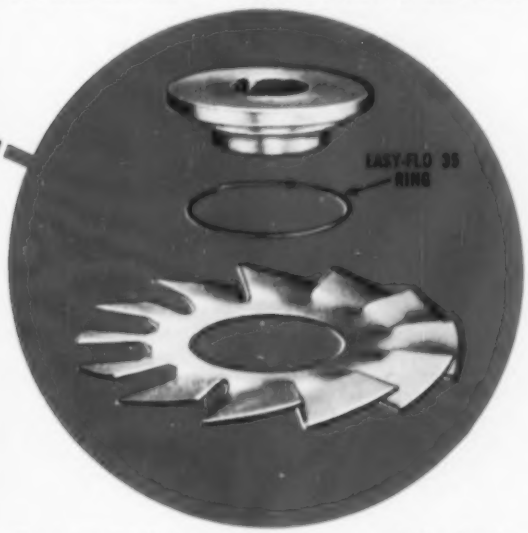
EASY-FLO and SIL-FOS are such tools. These low-temperature silver brazing alloys provide, not only the widest *versatility* in joining metals, but also the basis for surprisingly *simple, fast, economical production.*

A FINE EXAMPLE FROM BLACK & DECKER



Fans for B&D portable drills are made by brazing steel hubs into stamped steel blades on the city gas-air setup shown. Parts are degreased and assembled, with a ring of EASY-FLO 35 dipped in Handy Flux and preplaced between hub and blade. Mechanism moves assemblies along under burners. An assembly is completed every 6 seconds! One operator does it all!

SPECIAL BRAZING ALLOYS

Over half a century of silver brazing alloy research, development and production, makes Handy & Harman the place to go for technical assistance in working out special brazing problems. The comprehensive range of special silver brazing alloys offered by Handy & Harman meets a wide range of special requirements. Consult us without obligation. Contact the nearest office below.

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It explains the many advantages of EASY-FLO and SIL-FOS brazed construction—and why these alloys assure fast, low-cost production of high-strength, virtually indestructible joints. Write for a copy today. With it we will send a list of EASY-FLO and SIL-FOS Distributors. There's one near you.

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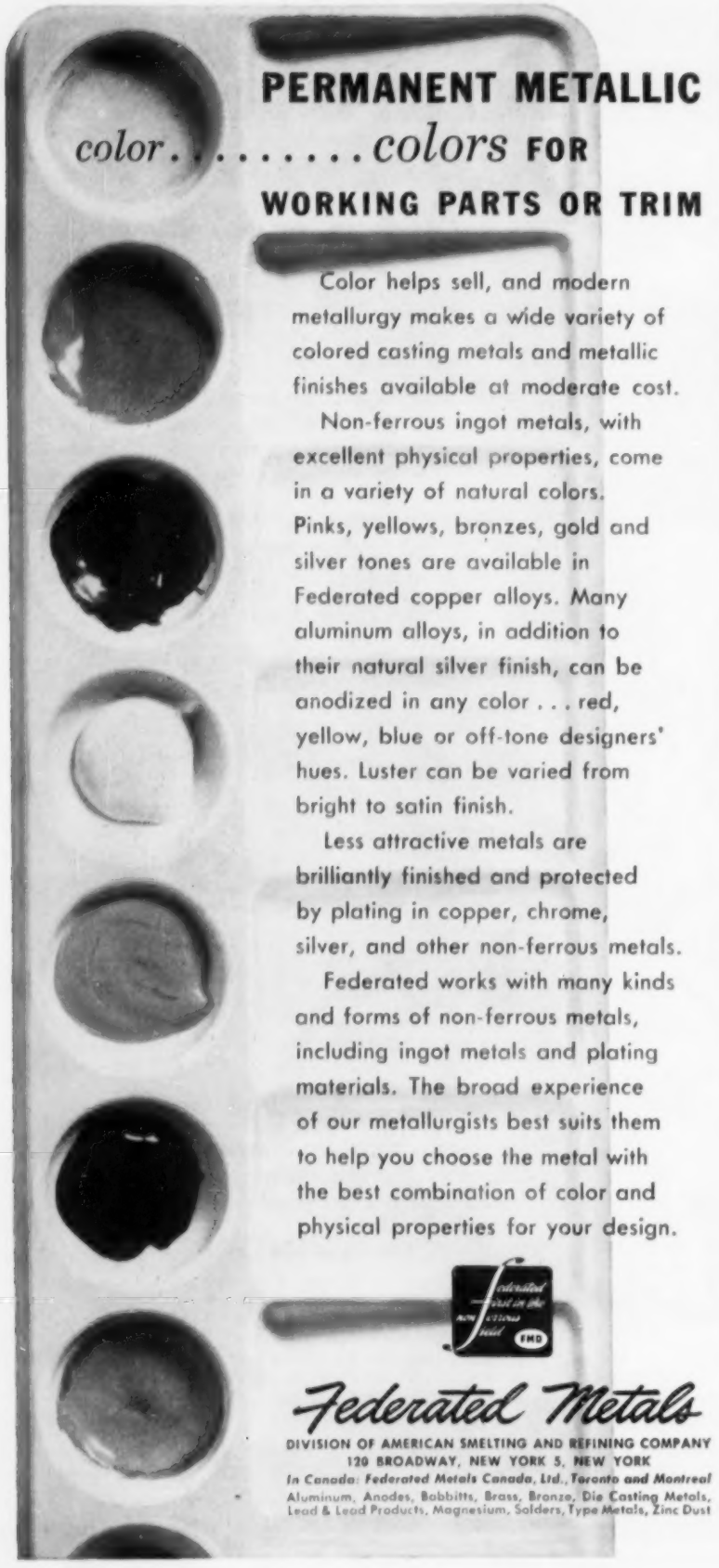
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Molten Metal . . .

mercury was piped to a heat exchanger and cooled to its normal boiling point at atmospheric temperature (370° C. or 700° F.) the solubility of iron dropped to about one-quarter the original. The result was that a circulating stream of hot mercury transported iron from a hot region to a cool region, and the cool piping became clogged with feathery iron crystals in a distressingly short time. It was later found that a little titanium and magnesium dissolved in the mercury prevented this action; the reason was uncertain although it was suspected that the principal function of the magnesium was to react promptly with any oxygen which might get into the circuit. Such "corrosion" might more properly be called "mass transfer".

This old problem has arisen to plague even more severely atomic reactors designed to use liquid metal for heat transfer agents, because the metals favored for their low nuclear cross section (that is to say, their low absorption of valuable free neutrons) are a lead-bismuth eutectic and bismuth with 0.1% uranium. Bismuth is a much more "corrosive" metal at high temperatures than mercury; the solubility of iron in bismuth is on the order of 100 times as high as its solubility in mercury at the same temperature. Likewise, the temperature coefficient of solubility is somewhat larger.

Mass transfer of iron in such bismuth alloys has been extensively studied at Brookhaven National Laboratory using a simple rectangular loop of pipe. One vertical leg of this is kept hot by electrical windings; the other leg is bare and cooled by fans. The thermal head is sufficient to keep up a slow steady circulation of the liquid metal, which also carries over iron, and plugs the cool leg in fairly short order. Mr. Gurinsky's paper contains such experimental data for a number of standard piping materials used in high-temperature installations. None are immune to mass transfer *unless* the circulating liquid metal contains in solution minor amounts of zirconium or titanium – respectively 0.4 weight % and 0.001 weight % – plus 0.01 weight % magnesium or 0.25 weight % aluminum for deoxidizers.

The mechanism postulated for this

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See page 11
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You'll want to know the answers

Can one cleaning material do all metal-cleaning jobs? *See page* 5.

What kind of cleaner attracts both oil and water? How does this help remove buffing compound residues and pigmented drawing compounds? *See page 8.*

Why clean ferrous and nonferrous metals in separate tanks? *See page* 10.

What are the advantages of reverse current for electrocleaning steel? *See page 15.*

For electrocleaning nonferrous metals, what are relative advantages of cathodic, cathodic-anodic and soak-anodic cleaning? *See page* 17.

Can you electroclean brass without tarnishing? *See page 18.*

How do bright dips make metals brighter? *See page* 21.

Can you clean steel and condition it for painting for less than 20 cents per 1,000 square feet? *See page 24.*

Would you like a cleaner that removes rust and oil at the same time; often eliminating all need for pickling? *See page* 28.

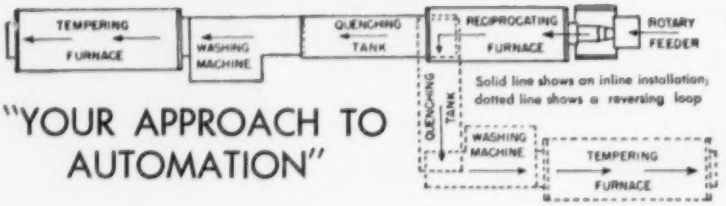
What's the best way to clean parts that are too large to be soaked in tanks or conveyed through washing machines? *See page 30.*

Does your burnishing barrel produce a luster you are proud of? *See page* 32.

What do you do when the overspray neither sinks nor floats in the wash water in your paint spray booth? *See page 35.*

Do you dry steel parts before anti-rusting? *See page* 37.

AGF Heat Treating Installation Cuts Costs



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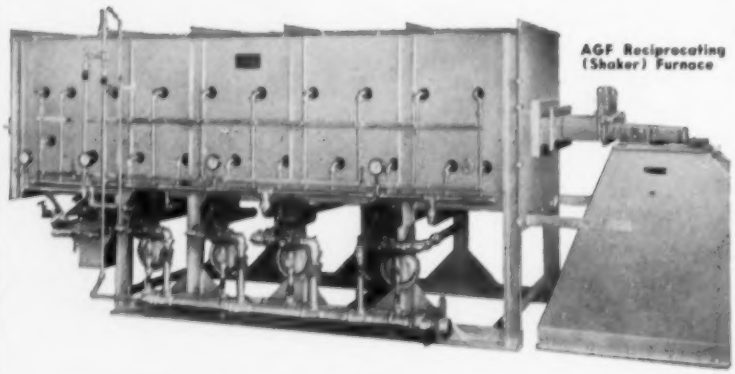

AGF Reciprocating (Shaker) Furnace

A complete AGF Automatic Continuous Heat Treating Installation consists of an Automatic Rotary Feeder, a controlled Atmosphere Reciprocating Furnace (illustrated above) and an Automatic Quenching Tank followed by a washing machine and Tempering Furnace.

The output ranges from 100 to 800 lbs. of controlled atmosphere heat treating, quenching, washing and tempering per hour. A wide range of sizes cuts costs; the unit is suitable for a small plant or can be fitted into a production line in a large plant.

The installation can be made either in line or in a reversing loop as illustrated. The reversing loop discharges the work next to the charging end of the furnace and uses a minimum of floor space.

Each part is individually heat treated and quenched as it passes through the reciprocating furnace and quench tank. The disadvantages of batch processing are eliminated.

Flexibility permits handling small as well as large production lots on a continuous basis. Large production lots can be interrupted easily to run small batches of urgently needed work.

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extraordinary protective action of zirconium or titanium is most interesting: Mr. Gurinsky believes that these two elements form nitrides with the nitrogen in the steel – at the very surface, of course – and gradually deposit a layer of nitride as more nitrogen diffuses to the depleted surface from within the steel itself. These nitrides form a continuous protection for the metal. Such a surface would also be self-healing. Zirconium and titanium nitrides are among the hardest and most stable chemical compounds known.

Evidence in favor of this theory comes from at least two sources: When the loop is made of "pure iron" – that is, iron with vanishingly small content of nitrogen – zirconium or titanium is no longer protective. Secondly, when radioactive zirconium or titanium is used to doctor the liquid bismuth, the inner surface of the hot leg of the steel tube shows the presence of these tracers.

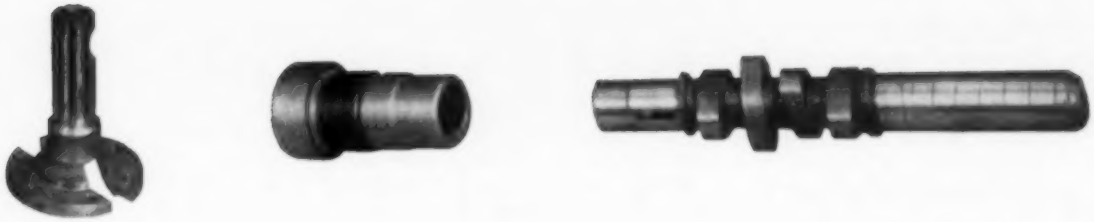
E. E. T.

Fusion Welding of a High-Strength Aluminum Alloy

Digest of "Fusion Welding of 24 S-T 3 Aluminum Alloy", by J. B. Arthur, *Welding Journal*, Vol. 34, November 1955, p. 558s-569s.

Most aluminum alloys have a wide thermal solidification range which causes difficulty in fusion welding. In the high-strength alloys like 2024 (24 S), strength and ductility are decreased in the heat-affected zone adjacent to the weld. Since such alloys are important in aircraft applications and fusion welding could save weight, simplify design and reduce cost, North American Aviation, Inc. has conducted an extensive investigation to determine how to make high-strength welded joints in 2024-T 3.

Strength of the parent metal in this alloy is about 69,000 psi. It decreases when heated for short periods in the range from about 500 to 950° F., reaching a minimum of about 50,000 psi. at 700° F. Above 950° F., the strength again decreases



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Welding Aluminum . . .

rapidly to about 36,000 psi. after exposure at 1100° F. A good joint can be prepared if heat transfer to the parent metal is minimized so that there is no overheating. With no overheating the sample can be returned to its original condition by a solution anneal.

Joint strengths greater than 62,000 psi. were obtained by the argon-shielded tungsten-arc process using an automatic machine. The filler wire was 4043 (43 S). After welding, the samples were water quenched from 920° F. and artificially aged at 375° F. for 12 hr. Precise control of welding speed and current, the use of well-designed jigs and two or more weld passes, and thick weld beads were all important factors. Some of the requirements for the welding jigs included:

1. Uniform consistent quenching of material adjacent to the weld must be provided. In order to obtain this continuity and contiguity between the hold-down bars and shoes, the work (base material) and the back-up bars must be held and maintained for the complete linear length involved. Hold-down bars must be parallel to each other and to the centerline of the groove in the back-up bar. Pressure must be uniform against the work and be precisely controlled and maintained for duplication of weld quality.

2. Material for back-up bars, hold-down bars, and shoes must have high thermal conductivity, not be weldable to aluminum or its alloys and have a fair degree of wear and abrasion resistance. It must also hold its shape under application of heat and pressure.

3. Jigs must be designed so that under operating conditions no distortion or deformation of the work occurs.

4. In the actual mechanical application of pressure on the sheets there must be no lateral force which would open up the seam. Actually it is desirable to have two components in this mechanical movement – a horizontal tightening (upset) of the seam accompanied by a vertical hold-down pressure.

Before this investigation was made, the joint strength expected from inert-gas-shielded tungsten-arc welding was 47,000 psi. By comparison, riveted joints were rated at 47,000 psi., seam welds at 27,000, oxy-hydrogen welds at 40,000 and inert-gas-shielded metal-arc welds at 43,000 psi. The values for tungsten inert-gas welds for ¼-in. sheet have been raised to 53,000 psi. as welded and 62,000 psi. after solution treatment and aging.

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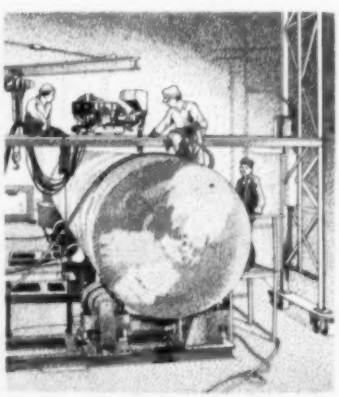

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Competitive Oil B	729	39.0
Competitive Oil C	1024	41.0
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*Based on a recognized formula for determining relative cooling power value. Measured as the square of the current (I^2max.) as recorded by Quenchol Demonstrator.

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SINCLAIR METAL WORKING OILS

Aluminum Versus Copper

Digest of "Aluminum Vs. Copper for Step Regulators", by C. W. Nielsen, *Allis-Chalmers Electrical Review*, Vol. 20, No. 4, 1955, p. 28-30.

TO JUSTIFY the conversion from copper-wound to aluminum-wound units in step regulators, the following conditions must be met:

1. The units must be electrically and mechanically equal.
2. The over-all size should be approximately the same.
3. The cost of manufacturing must be equal.
4. Material must be available in sufficient quantities.

All connections that are brazed in the standard copper-wound units are either brazed or welded in aluminum units. Connections between aluminum and copper must be kept under oil, to eliminate galvanic corrosion problems.

Inert-gas shielded-arc welding provides an excellent electrical and mechanical connection between aluminum parts. Brazing or welding aluminum to copper, however, is more difficult. Special techniques are required in the application of heat to both metals. Tension is maintained on a copper winding while brazing but when this procedure is followed with aluminum wire, the aluminum connections separate.

Copper-to-aluminum flash welds and pressure connections are used on the higher-current units. The flash welds are made on a special machine which brings the two metals together rapidly while drawing an arc. Although the interface in the joint is thin, it is still brittle. The aluminum end of this connection is heliarc welded to the aluminum tap lead and copper brazing is used for connections to the tap changer.

After disappointing experience with brazed or welded aluminum-to-copper joints, it was decided to use flash welded or "Koldweld" pressure connections in subsequent units. Both kinds of joints have higher tensile strength than aluminum. In bending fatigue tests the pressure connections failed in the aluminum and not at the joint. The flash welded connections failed at the interface in every instance. Resistivity of the pressure connection varied from 91 to 102% of the parent metals, while that of the flash weld ranged from 107 to 142%. Heliarc welding or copper brazing within 1½ in. of the joint did not change the conductivity of the pressure connection but affected its strength adversely. Such welds and brazes must be made at least 4 in. from a flash welded connection.

Aluminum units are practical both electrically and mechanically. Aluminum-wound, step-type oil-filled regulators can be made equal to copper-wound units in quality. However, copper-to-aluminum connections of the "Koldweld" type are preferred and these connections should be located under oil. The necessary increase in dimensions may be a handicap where installation will be in cubicles of limited dimensions. In pole and substation installations the aluminum-wound units should offer no problem, since space is generally available and weights are essentially the same. Although the cost of equivalent aluminum magnet wire is gen-

(Continued on p. 170)

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main valve seat for fire plug

Sand-cast pegs bent easily, causing improper fire plug operation. Full line pressure could not be maintained. Machining often uncovered blow-holes causing rejects. Switched to brass forging for higher strength, dense structure, closer tolerances, reduced over-all costs.

multi-port valve body

Porous sand-cast part caused non-detectable leaks in air and fluid system tests. Switch to fine-grained brass forging stopped trouble. Rejections, scrap, costs all reduced. Closer tolerances and better appearance achieved by using brass forging.

base for TV signal transmission

Porosity and blow-holes in sand-cast part caused "high standing wave," or loss of power feeding into TV transmitting tower through base on end of cable. This required tearing down whole assembly at considerable cost. Switch to dense, strong forging eliminated rejects and power leakage.

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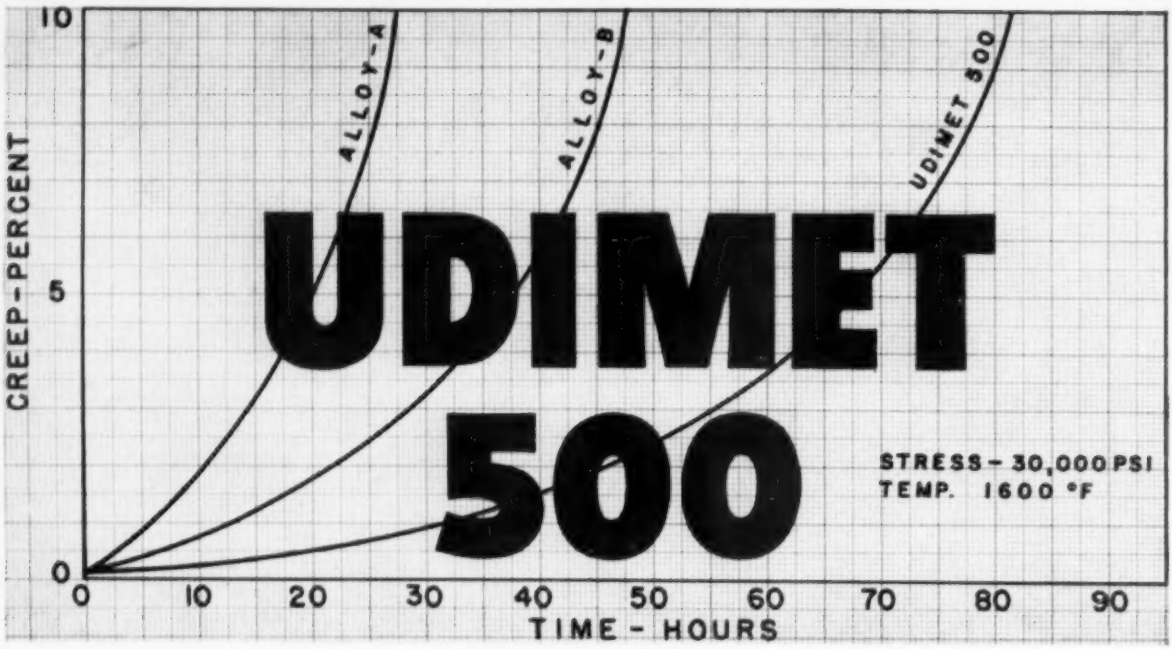

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Al Vs. Cu . . .

erally lower than copper, the greater fabrication expense increases the over-all unit cost of aluminum-wound regulators as compared to copper-wound units. At present aluminum-wound regulators are not economical but if the cost differential between aluminum and copper continues to increase, they may become so.

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J. M. H.

Gas Carburizing Under Pressure

Digest of "Gas Carburizing Under Pressure", by O. P. Sorokina and D. I. Bron, *Metallovedenie i Obrabotka Metallov*, No. 1, 1955, p. 47-50.

Two processes are involved in carburizing, one that takes place at the interface between the metal and the carburizing medium and another that occurs in the steel itself. The first process involves the two carburizing gases carbon monoxide and methane which break down and form carbon at elevated temperatures. Two molecules of carbon monoxide form one molecule of carbon dioxide and one of carbon. One molecule of methane forms two of hydrogen and one of carbon. Le Chatelier's principle predicts that an increase in pressure should promote the first reaction and depress the second. The effect of varying the pressure from 1.1 to 2 atmospheres does have an appreciable effect on the gas composition only at relatively low temperatures. The effect can be neglected at 1700° F., which is the carburizing temperature.

The reaction of carburizing gases with iron must first saturate the austenite with carbon and then form cementite. The reaction of iron with carbon monoxide decreases the number of gas molecules so that an increase in pressure should increase the rate of reaction. The reverse is true for methane. At higher pressures there will be more carbon atoms per unit area of metal surface available

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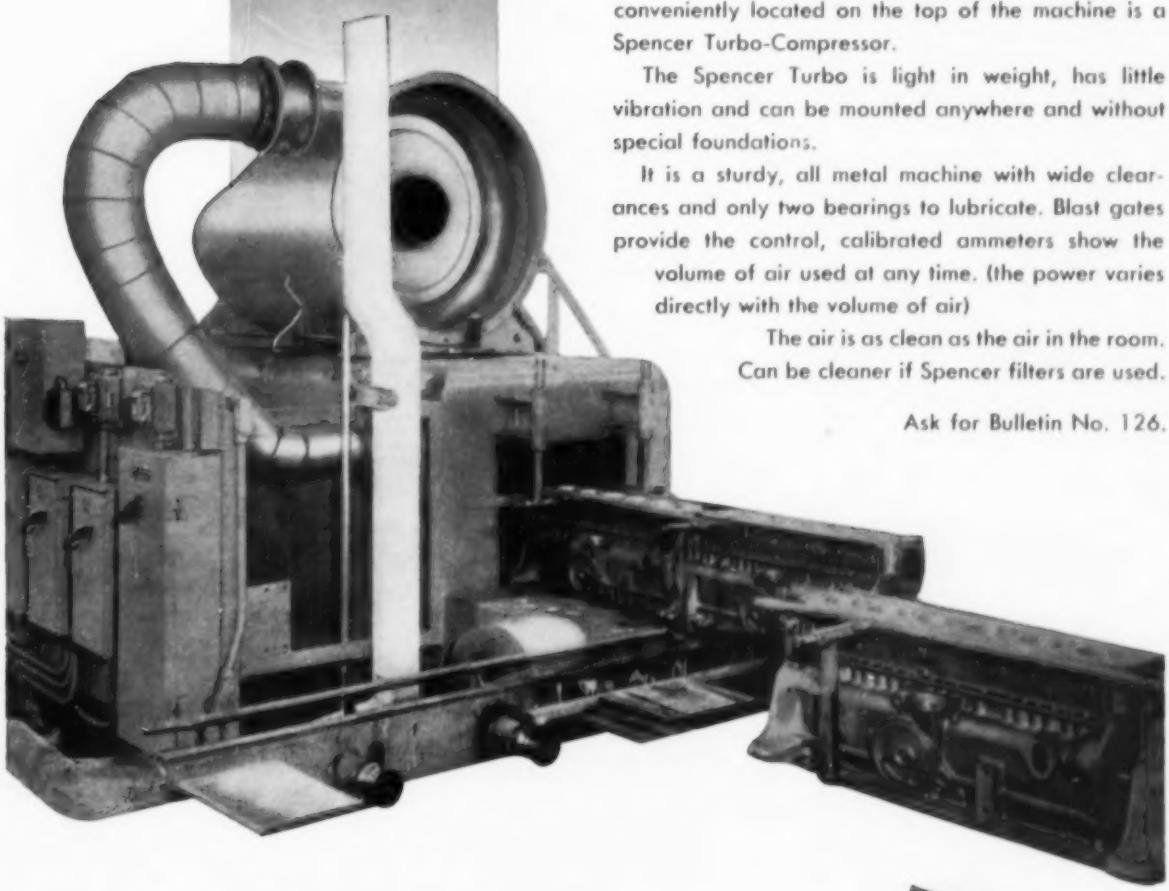

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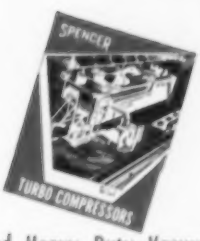

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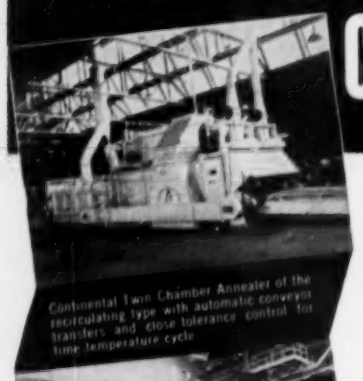

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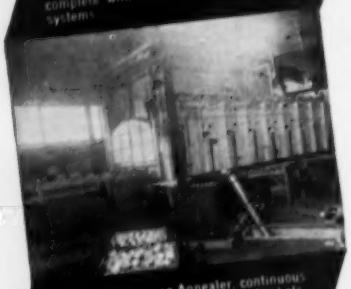

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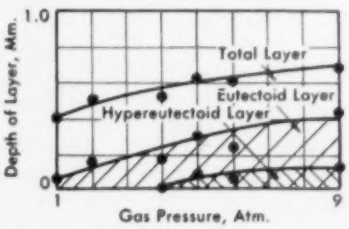
Carburizing . . .

from carbon monoxide and the rate of saturation of the metal surface will increase.

Diffusion inside the metal is not directly influenced by pressure. However, the acceleration of the saturation of the steel surface at higher pressures can increase the concentration gradient and thus increase the amount of carbon transported by diffusion.

Specimens $10 \times 10 \times 50$ mm. made from Russian steel No. 20 (0.20% carbon, 0.30% silicon and 0.65% manganese) were used for this study. The carburizing temperature was 1700° F., and the carburizing medium was illuminating gas dried with silica gel. The gas contained 54% CH_4, 30% H_2, 7.5% CO, 5.0 N_2 and 1.5% CO_2. At the completion of carburizing the specimens were cooled in sand heated to 150° F.

The structure of the carburized case changed markedly as the pressure was increased from 1 to 9 atm. as shown in the diagram. The hyper-



Effect of Pressure of Carburizing Gas on the Case Structure

eutectoid layer first appeared at 4 atm. and reached a thickness of 0.11 mm. at 9 atm. Carburizing time was one hour with an additional ten minutes being allowed for the specimens to reach the carburizing temperature. Longer carburizing time increases the thickness of each layer but otherwise the results are similar to those obtained in one hour.

These experiments show that higher pressures accelerate the process of saturation of the surface layer of the steel with carbon. Consequently there is a sharper concentration gradient and an increased amount of diffusion. The effect of the acceleration of diffusion extends only to a shallow depth, so the total case is only slightly increased at higher pressures.

A. G. GUY

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Corrosion of Lead-Base Babbitt Alloys

Digest of papers presented at a symposium on "Lead-Base Babbitt Bearings" sponsored by the American Society of Mechanical Engineers, 1952.

BEFORE tin became scarce in the early 1940's all babbitt alloys contained 87 to 91% tin; the balance was antimony and copper. Structure of these alloys consists of hard crystals of a copper-tin compound embedded in a softer antimony-tin solid solution. Lead-base babbitt, containing 74 to 84% lead, 10 to 15% antimony and 1 to 10% tin, was developed to conserve tin and is less expensive than the tin-base alloy. It contains hard antimony-tin crystals in a softer matrix, and has greater load-carrying capacity than the tin-base alloy. Its corrosion resistance, however, is inferior.

Although other bearing metals such as silver, aluminum, cadmium and leaded bronze have better resistance than the babbitts to fatigue under load, the babbitts are preferred because of low friction, good wettability by oils, conformability to misalignment, embeddability of foreign particles or dirt and resistance to corrosion by oxidized oils, volatile acids and sulphur from inhibitors in the oil.

In the principal paper of the symposium the corrosion of lead-base babbitt bearings in service, first noticed in 1944, is discussed in great detail. This corrosion led to darkening and thickening of the lubricating oil and the appearance of a dark gray matte surface on the babbitt. These were followed by rapid wear and serious impairment of lubrication due to excessive viscosity of the oil. Laboratory tests of bearings polished to an abnormally smooth surface showed that although the oil darkening and thickening were less serious with more highly finished surfaces, mechanical factors were not of prime importance. The chief cause of the trouble seemed to be a chemical reaction between the babbitt and the oil. The oil preferentially attacked the alpha phase, which is nearly pure lead containing a little antimony in solid solution.

The typical oil contamination produced by lead-base babbitt bearings in service was duplicated in the laboratory with a straight uninhibited turbine oil by adding 1% oleic acid or 2% lard oil, and heating 30 to 70 hr. at 200° F. in contact with low-tin babbitt shavings. If the tin content was 7.5% or more the oil did not discolor. Although corrosion of lead-base babbitt strips occurred slowly under static conditions, a rubbing action was required to contaminate the oil and accelerate the corrosion.

Some systematic tests were made on machined samples of various babbitts in oil with and without oleic acid. The test temperature was held at 175° F., and oxygen was bubbled through the oil at a rate of 0.023 cu. ft. per hr. A tin-base babbitt was unaffected in all oil mixtures, and various lead-base babbitts were also practically unaffected in the plain oil. With 0.25% oleic acid in the oil, the lead-base babbitt with only 1.1%

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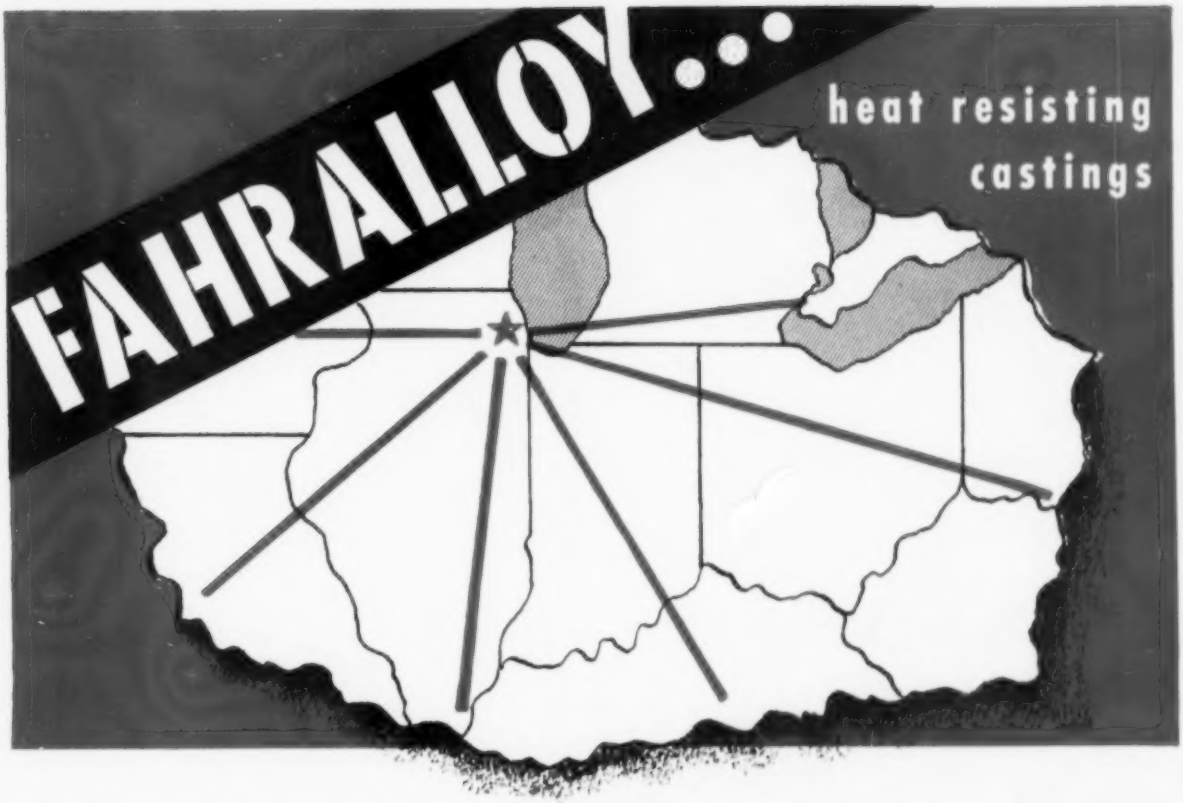

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Babbitt Alloys . . .

tin lost about 700 mg. in 80 days, while those with 2.5 to 8.5% tin lost only about 10 mg. With only 0.05% oleic acid in the oil the lead-base babbitt with 1.1% tin lost 150 mg. in 80 days. With an oxidation inhibitor added, this alloy resisted corrosion about as well as those with 2.5 to 8.5% tin. The oil oxidized only when in contact with the 1.1% tin babbitt and to a much greater degree with 0.25% oleic acid in the oil than with 0.05%. Sludge formation and increased viscosity also required both oleic acid and babbitt in the oil.

These results support a previously published statement that about 3% tin is required in a lead-base babbitt for good corrosion resistance. The tin prevents catalytic oxidation of the oil. Acidification of the oil by oxidation alone did not lead to corrosion of low-tin babbitt; the fatty acid was also required. With that acid present, the corrosion was the same whether oxygen or nitrogen were bubbled through the oil. Similar corrosion in service is accounted for by the ease with which mineral oil may be contaminated by such agents as cutting oils, sludging oils and miscellaneous organic dirt. The safest way to avoid corrosion is to have at least 3% tin in the babbitt instead of trying to keep the oil free from fatty acid.

When the formation of peroxides and acids in the oil is prevented, high-lead babbitts give satisfactory service. In large installations this can be accomplished by keeping the oil clean and inhibited. In medium-sized motors, maintaining clean and inhibited oil is a difficult problem and tin-base babbitts have been preferred though their greater cost is really not justified. In small motors the oil may deteriorate rapidly and the bearing cost is small, so tin-base babbitt is definitely preferred.

G. F. Comstock

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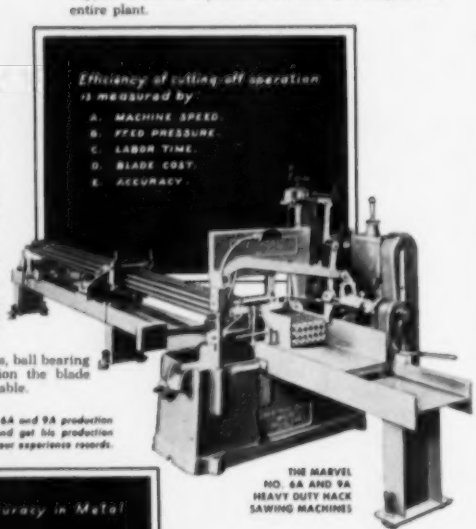

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Electrolytic Polishing of Aluminum

Digest of "Metallography of Aluminum and Its Alloys—Use of Electrolytic Polishing", by P. A. Jacquet. Translation by M. L. Mahler, N.A.C.A. Technical Memorandum 1384, November 1955, 80 p.

In the first part of this lengthy report, 109 references are given to papers published from 1947 to 1950 which mention metallographic electrolytic polishing of aluminum alloys. The particular use of the process is noted for each reference and they are classified according to the electrolyte used. Jacquet expresses his preference for a solution containing one part perchloric acid to two parts acetic anhydride. He warns against false interpretation of surface appearances produced by electrolytic polishing in other solutions which may form a film of alumina on the specimen.

The electrolyte consisting of one part perchloric acid and four parts ethyl alcohol is recommended by the Royal Aircraft Establishment in England as easily prepared, non-explosive and rapid in action. It is suitable for polishing many aluminum alloys. Although intermetallic compounds may be left in relief, the relief is usually less than produced by mechanical polishing. With some alloys a jet of hot water and light rubbing on a cloth with alumina are required to remove the surface formed by the solution.

Chemical polishing, or "superpolish", by immersion in acid solution without any electric current has been used commercially for aluminum alloys, but the results are not good enough for metallography, or

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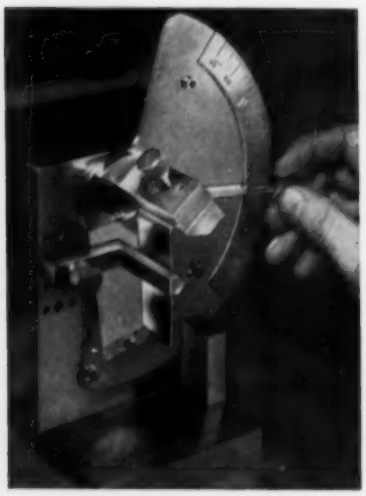

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Electrolytic Polishing . . .

at least not without more precise control than is required in electrolytic polishing. A concentrated alcoholic solution of hydrochloric acid has been used for polishing the surface of magnesium. Aqueous mixtures of phosphoric and nitric acids (with or without acetic or sulphuric acids) can be used at high temperatures for aluminum alloys. The time required depends on the alloy and the surface quality of the specimen. A mixture of 70% H_3PO_4, 25% H_2SO_4, and 5% HNO_3 has been recommended for preparing specimens of aluminum for metallography, but not by Jacquet.

For studying recrystallization and grain growth in aluminum, anodic oxidation is useful. After electrolytic polishing in an electrolyte containing 53% of 85% H_3PO_4, 26% H_2O, 20% carbitol (mono-ethyl-ether of diethylene glycol) and 1% of 48% HF by volume, anodic oxidation is produced in the same bath with lower voltage and current. The sample is then heated at the temperature of interest and re-oxidized anodically. The changes in structure due to the heating may be followed with the microscope because the prior structure is not removed completely when the new anodic oxidation is applied.

A machine for polishing specimens electrolytically is described in detail. This machine, called the "Disa-Electropol", is made by H. Struers Chemiska Laboratorium in Denmark. It is highly recommended by Jacquet for use on aluminum alloys. The electrolyte is kept in strong circulation by means of a pump, and the voltage and time are controlled by instrument settings. With specimens ground on 00 emery paper, the polishing time is 5 to 20 sec. The electrolyte recommended for steel, zinc, lead, silver and Nimonic alloys is 200 ml. perchloric acid, 700 ml. ethyl alcohol, and 100 ml. glycerine. For aluminum alloys, the glycerine in the above formula should be replaced by butyl cellosolve (glycol monobutyl ether). The voltage is generally between 35 and 45, and the current density 150 to 175 amp. per sq.dm. The electrolyte is circulated rapidly to avoid excessive heating of the specimen. Etching after polishing may be performed

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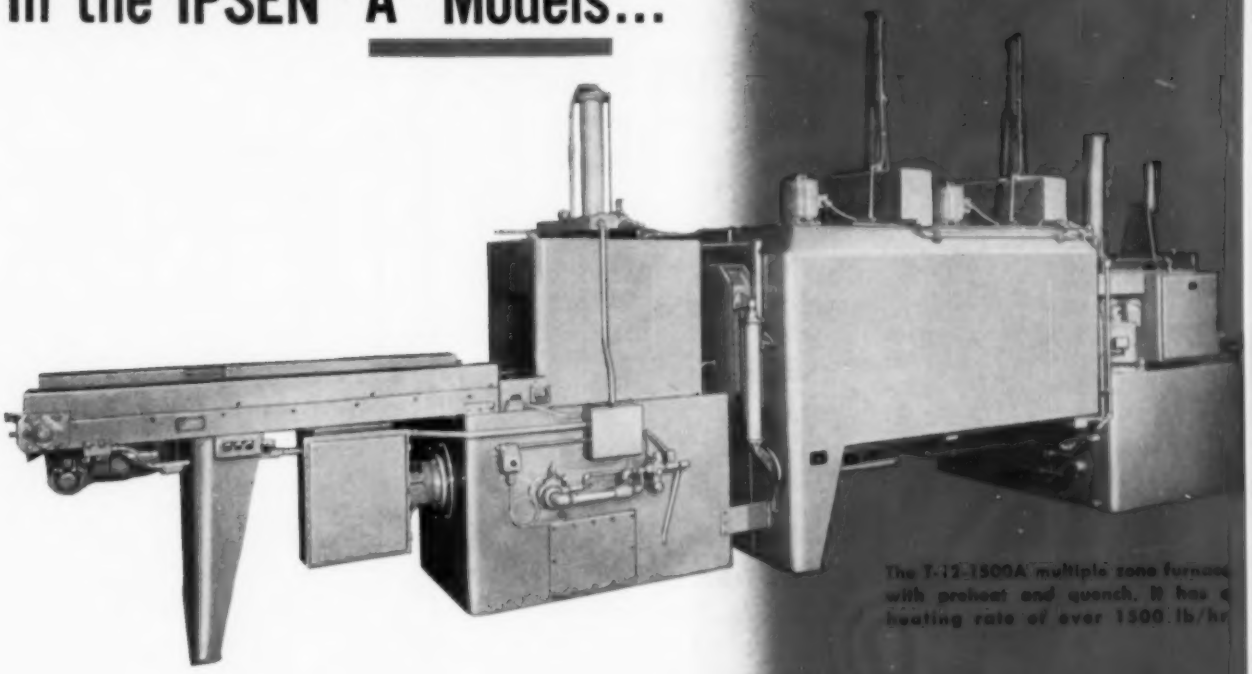

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Electrolytic Polishing . . .

electrolytically in the same apparatus and solution by merely reducing the voltage to 3 to 4.

The Disa-Electropol machine has polished all types of aluminum alloys very successfully for microscopic examination. The fact that the specimen is not heated, which may occur in some other methods, is an important advantage. A disadvantage is that polishing is confined to areas no larger than 1 sq.cm. The electrolytic polishing method of most general utility is the older one using perchloric acid and acetic anhydride as the electrolyte. It does not produce a harmful oxide layer and the current is sufficiently low to avoid heating.

G. F. COMSTOCK

Graphitization of Fe-C-Si Alloys

Digest of "Reactions Involved in the First-Stage Graphitization of Iron-Carbon-Silicon Alloys", by W. S. Owen and J. Wilcock, *Journal* of the Iron and Steel Institute, Vol. 182, January 1956, p. 38-43.

WHEN white cast iron is heated at a graphitizing temperature for a longer time than is required for complete graphitization, the smaller graphite nodules dissolve in the austenite while carbon continues to be deposited on the larger nodules. Thus the saturation concentration of carbon in austenite depends on the radius of the adjacent graphite nodule in the austenite; conversely, the solution potential of a graphite nodule depends on the size of the nodule as well as on the carbon concentration in the surrounding austenite. No re-solution of small graphite nodules into austenite occurs until the solution of cementite fails to maintain the carbon in the austenite while precipitation of graphite on the large nodules is going on. Until about 70 to 100% graphitization occurs, no decrease in the number of nodules is observed. Later, as the smaller nodules are dissolved, the remaining large nodules become more isolated and the increasing diffusion distance retards the action.

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Graphitization . . .

containing 3.38% C and 1.13% Si the number of graphite nodules per cu.mm. increased linearly from about 22,500 after 15 min. heating at 1780° F. to over 40,000 at 40 min. and then decreased to about 34,000 at 55 min. Up to the maximum, corresponding to about 70% graphitization, the rate of nucleation frequency per unit volume was evidently constant. Nucleation occurs only at cementite-austenite interfaces, and submicroscopic foreign particles are not required for its initiation.

The growth of graphite nodules at each of four temperatures is illustrated by curves showing the maximum nodule diameter after heating for various periods. These curves at first are approximately linear, indicating a nearly constant rate of growth. This implies a nearly constant diffusion distance, although the cementite interface must move away from the graphite as the cementite dissolves. Later the curves show slower growth in accordance with accepted theory.

From measurements of cementite volume, curves indicating the rates of cementite solution were obtained. Plotted logarithmically, the solution rates gave linear graphs. The activation energy is 78,000 cal. per mole, compared with 63,000 for growth of graphite. Plots of the over-all reaction-rate curve as determined dilatometrically, the rate of graphite volume change and the rate of reciprocal cementite solution all coincide closely. This demonstrates that the rate of graphitization can be measured dilatometrically; the volume change due to cementite solution is negligible compared to that due to graphite formation.

Graphite nodules at first grow very rapidly; later the rate of isothermal radial growth remains nearly constant and then decreases. When the cementite has disappeared, a nodule either continues to grow or dissolves depending on whether neighboring nodules are smaller or larger.

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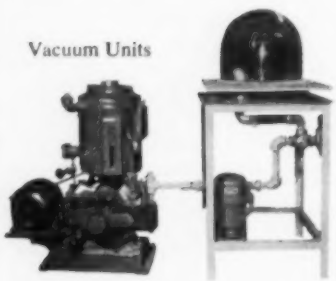

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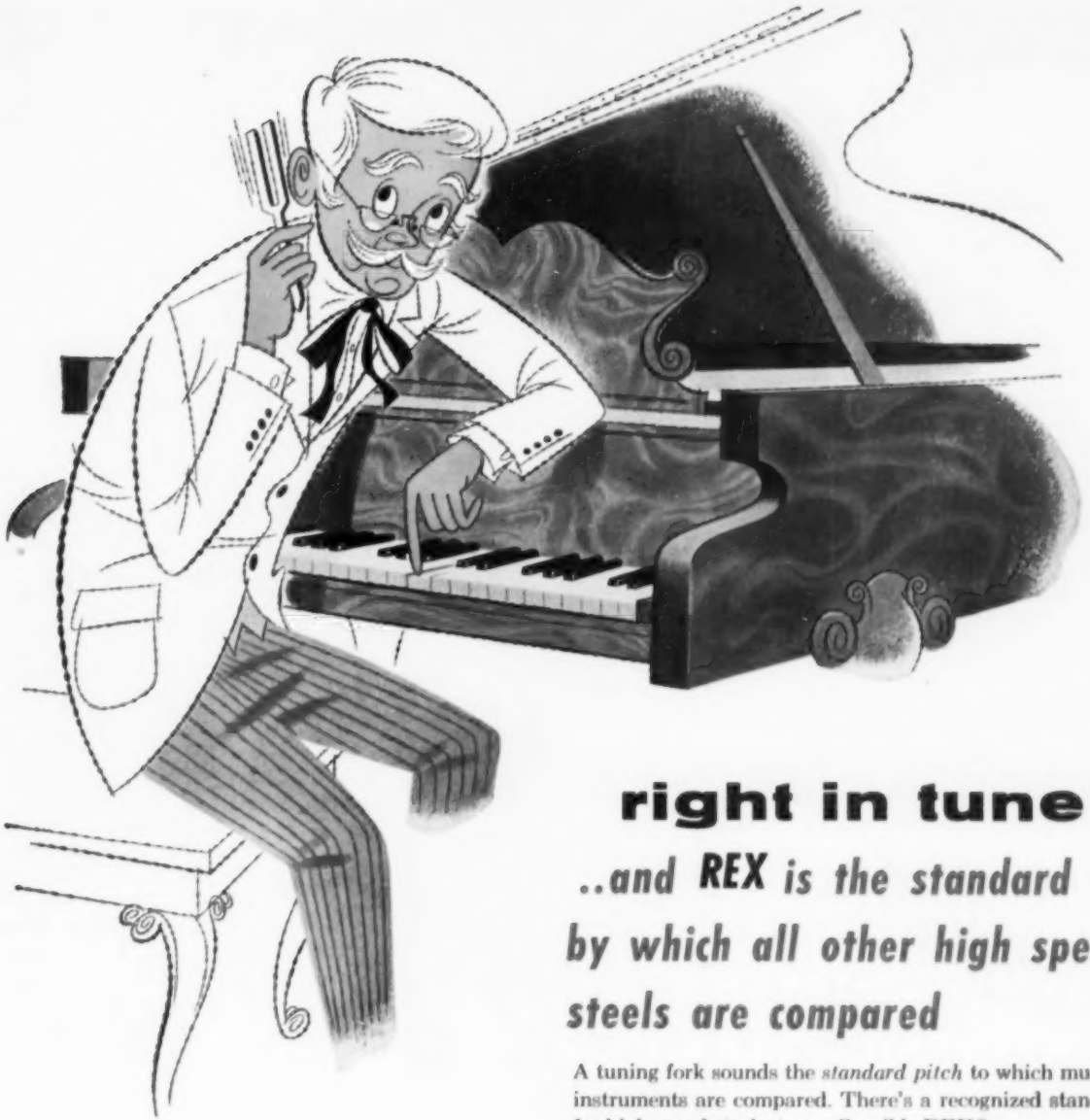
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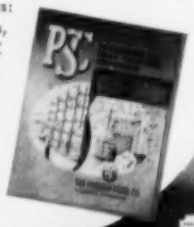

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WRITE FOR ILLUSTRATED CATALOG M 55

Graphitization . . .

temperatures the transition is very gradual; at high temperatures it is sharp. The reaction rate is controlled at first by the transfer rate of carbon from austenite to graphite. When the cementite is largely consumed its rate of solution may exert some control.

Since the austenite-cementite interfacial energy is an important part of the total energy for graphite nucleation, impurities in commercial cast iron may seriously affect graphitization through modification of the interfacial energy.

G. F. COMSTOCK

Effect of Oxygen on Porcelain Enamel Adherence

Digest of "Effect of Oxygen Content of Furnace Atmosphere on Adherence of Vitreous Coatings to Iron", by A. G. Eubanks and D. G. Moore, *Journal* of the American Ceramic Society, Vol. 38, No. 7, 1955, p. 223-226.

VITREOUS enamels are used on metals to provide protection against corrosion and to provide a decorative finish. Oxygen in the firing atmosphere plays a role in the adherence of such vitreous coatings to the metal. To obtain detailed information about the adherence mechanism the National Bureau of Standards conducted a series of experiments in which the oxygen content of the furnace atmosphere was varied when the same enamel containing varying amounts of an adherence promoter, cobalt oxide, was fired onto iron.

It was found that any decrease of oxygen in the furnace atmosphere requires a corresponding increase in the amount of cobalt oxide in the enamel. Enamels containing 3.2% or more cobalt oxide develop a weak but definite bond in furnace oxygen concentrations as low as 0.02%. When smaller amounts of cobalt oxide are present, a greater oxygen content of the furnace atmosphere is necessary for appreciable bond development.

The specimen blanks were of ingot iron, 4 × 4 × 0.047 in., pickled and then coated with the enamel

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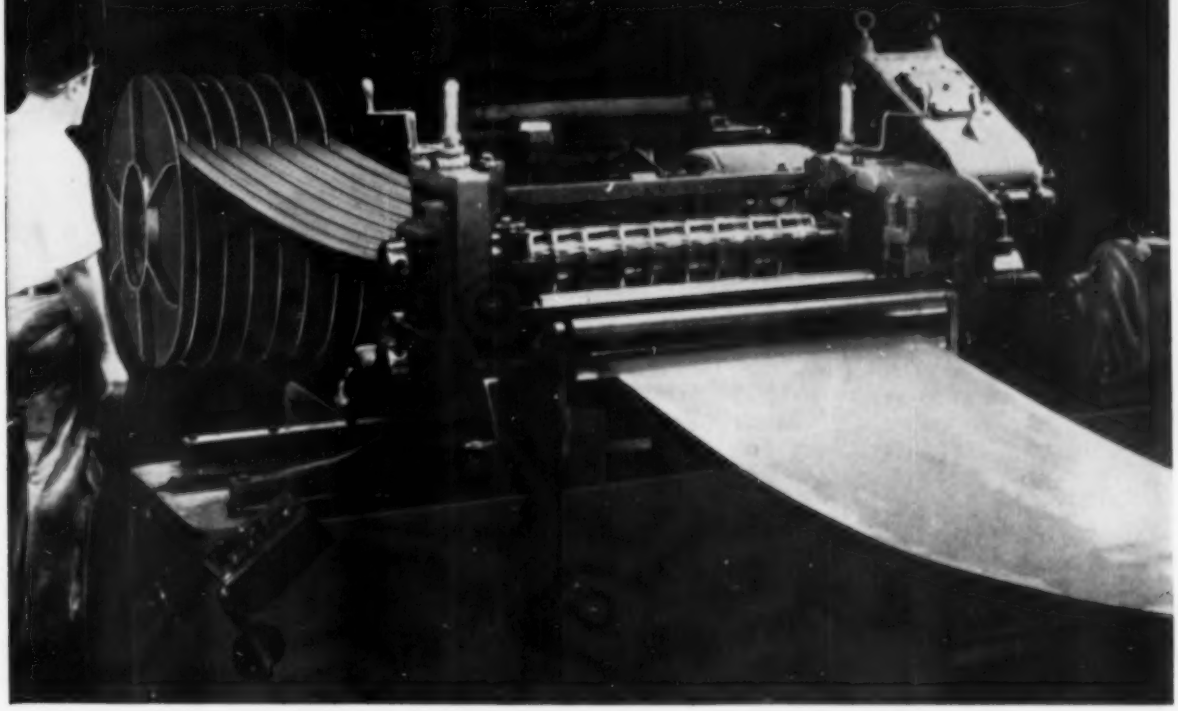

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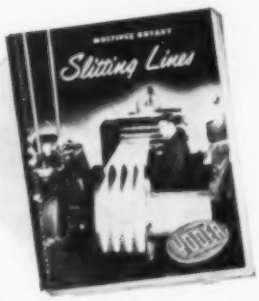

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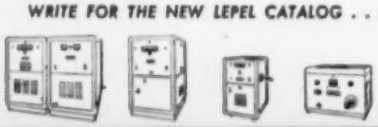

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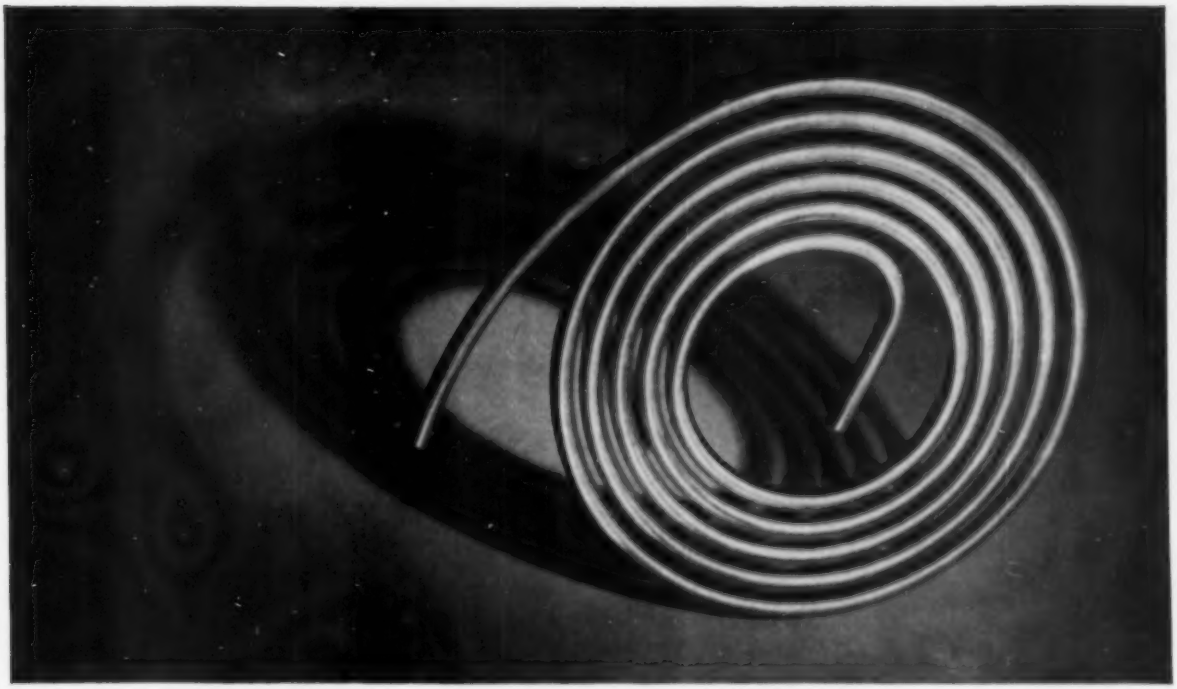
Enamel . . .

composition. The enamels contained varying quantities of cobalt oxide or cobalt oxide with manganese oxide, and were prepared according to standard procedures. Adherence of the fired enamel to the specimen was evaluated with the Porcelain Enamel Institute adherence meter. When used according to the A.S.T.M. test procedure, this instrument established the fraction of the test area to which the coating continues to adhere after the specimen has been deformed in the prescribed manner.

A coating containing 0.4% cobalt oxide developed its best adherence at an oxygen content of 20% – approximately that of air. Enamels with higher cobalt oxide contents reached their peak adherences at about 5% oxygen. Enamels with larger amounts of adherence oxides do not require as much oxygen in the furnace atmosphere as those with smaller amounts; this indicates that oxygen can be supplied from the enamel itself. The conclusion here is that the cobalt oxide is in some way supplying or facilitating the supply of some of the oxygen, since the amount of cobalt oxide is the only difference between the coatings. This conclusion is substantiated when the amount of cobalt oxide is plotted against adherence index for specimens fired in low oxygen concentrations. When the curves are extrapolated, they pass through the origin, thus indicating that cobalt oxide-free coatings have an adherence index of zero. With increasing cobalt oxide, however, the adherence index increases accordingly.

Metallographic sections were prepared of representative specimens. These showed that the adherence increased with increasing roughness of interface between the enamel and the iron.

Such roughening has been shown to occur during firing by what is believed to be a galvanic corrosion mechanism. The cobalt ions present in the coating layer tend to plate out of the molten enamel electrolyte as metallic cobalt onto the more electronegative areas of the iron surface. The tiny galvanic cells thus formed cause selective etching of the iron surface if the specimen is fired in an atmosphere containing a sufficient amount of oxygen. Little or no selec-



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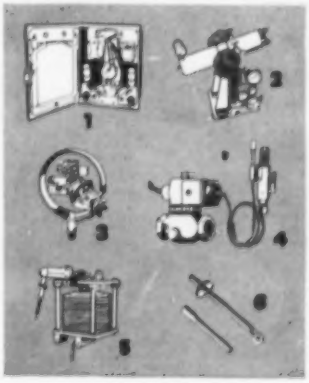

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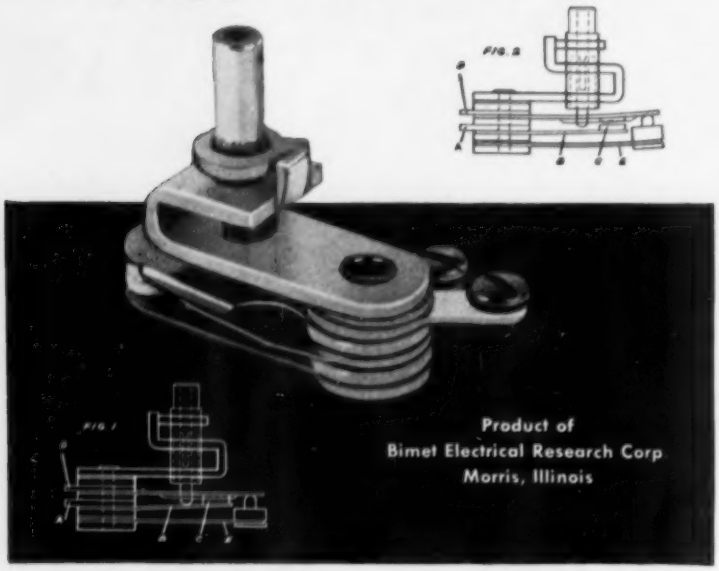
Belcor Thermostat



Belcor Thermostats are precision-made, custom-built at costs comparable with stock thermostats. Features of these thermostats include: elimination of false cycling and "chatter" of contact points by virtue of passing current through the independent contact springs rather than the bimetal member; although pre-calibrated, a trim screw inside the adjusting shaft simplifies re-adjustment or re-calibration; single stud mounting gives fast transfer of heat and a single through-hole facilitates assembly.

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Enamel . . .

tive etching will occur where there is insufficient oxygen present to promote the corrosion of the exposed areas of the iron. The oxygen required for the corrosion process does not necessarily have to come from the furnace atmosphere. If easily reducible oxides are present in the coating layer, then selective corrosion of the iron can still occur even in a furnace atmosphere that is substantially free of oxygen.

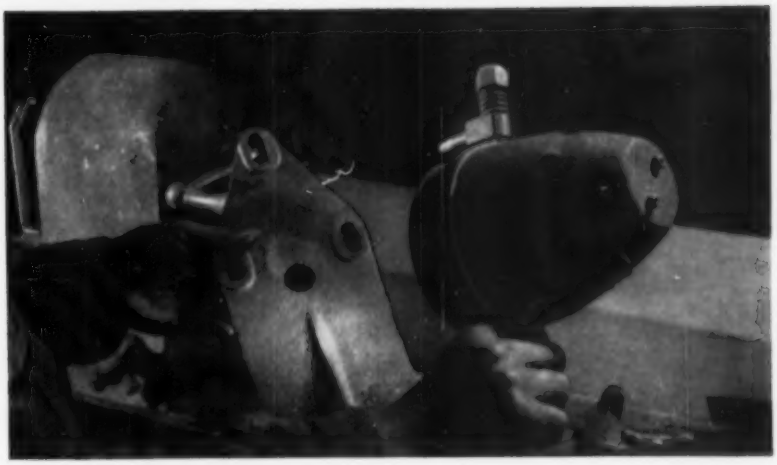
Interface roughness does not completely account for adherence; poor adherence has been observed on very rough interfaces and fairly good adherence has been obtained on alloys without surface roughening. Although the observations made in the present study can be explained on the basis of the galvanic corrosion theory, further work is needed to uncover and to isolate the other active mechanisms in the adherence of vitreous coatings to metals.

Corrosion of Iron by Oxygen-Contaminated Sodium

Digest of "Corrosion of Iron by Oxygen-Contaminated Sodium", by G. W. Horsley, *Journal* of the Iron and Steel Institute, Vol. 182, January 1956, p. 43-48.

LIQUID sodium has been used for cooling atomic energy reactors because even at elevated temperatures its interaction with the steel tubing is negligible. If the sodium is contaminated by Na_2O, however, it will corrode iron by formation of $(Na_2O)_2 \cdot FeO$. The variables that affect the corrosion were recently investigated at the British Atomic Energy Research Establishment in Harwell, England.

The materials used were 5-mm. rods of pure iron, Swedish iron powder, mild steel, pure sodium with and without oxide additions, and Na_2O produced by heating the reagent Na_2O_2 in a vacuum. In the first experiment the pure iron rods were heated in closed nickel-lined crucibles with sodium containing not over 0.3% oxygen. The atmosphere in the crucibles was argon. After heating seven days at 1470° F.,



Using Invisible Light to Find Invisible Cracks

A Peoria, Illinois foundry uses Magnaglo and "black light" to make any possible cracks on castings show up as glowing indications. Detection of flaws in the "rough" state means no wasted time in finishing defective castings. Early detection also makes the cause of defects easier to spot and correct. Result? Consistent quality and lasting customer satisfaction.

Inspection Methods: Case Studies

Lower Overall Production Costs Through Nondestructive Testing

Spotting Trouble Before It Happens

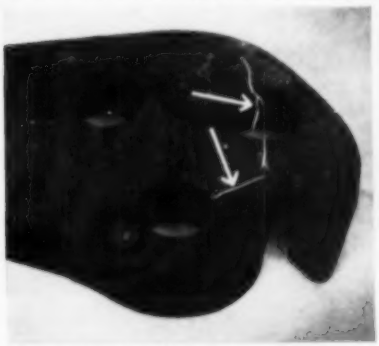
At the Bakelite Company plant in Bound Brook, N. J., inspecting reaction tanks is like seeing your dentist—should be done twice a year. A portable Magnaflux inspection unit is used to find cracked welds in tanks used in making the intermediate resins which go into Bakelite phenolic plastics.

Most manufacturers can achieve definite, worthwhile savings by employing one of the Mf methods for improved production control. These nondestructive inspection methods include: Magnaflux, for wet or dry magnetic particle inspection; Magnaglo, fluorescent particle inspection; Magnatest, eddy current electronic testing; Zyglo, fluorescent penetrant inspection; Spotcheck, dye penetrant inspection; and, Sonizon, for ultrasonic measurements.

The Mf testing methods are equally effective for preventative maintenance or manufacturing inspection.

Most manufactured products have as one, or more, of their components some type of casting, forging weldment, machined or formed part. Where cracks cannot be tolerated in the final product, maximum production economy must be obtained from the very outset. Flaws must be discovered as early as possible in order to eliminate further wasted effort in final processing or assembly.

Magnaflux methods pinpoint early flaws and help you eliminate their cause. This results in savings of time, labor and additional long range benefits from increased salvage and reduced amounts of scrap. For detailed information as to how one of the Mf inspection methods can help you produce better and save more, write or call for an interview with a Magnaflux engineer. No obligation, of course!



Heat Cracked the Jaw

The jaws of steel strapping machines must be reliable. Yet, following the heat treating, invisible cracks were discovered with Magnaglo as shown above. Immediate correction of the heat treat cycle eliminated the cracks. No further machine time or labor was expended on defective jaw parts.

Watching Your Weight

can be important—especially in the aircraft industry. Excess weight can reduce the range and payload of a plane. A major aircraft manufacturer uses Mf Sonizon units to ultrasonically measure thickness of sheet and formed shapes. This controls weight by eliminating excessive thickness.

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Sodium Corrosion . . .

there was appreciable weight loss from exposure to sodium containing 0.16% oxygen, and a golden incrustation was apparent on the sodium. When the iron specimens were heated in sodium containing 0.3% oxygen, the weight loss was very much less, possibly because of lower solubility of the corrosion product at this concentration.

Later, mild steel crucibles were exposed to sodium containing 0.5 to 10% oxygen. One that had contained sodium with 5% oxygen was found to be corroded extensively and coated with a loose scale containing iron particles. Analyses of the scale gave variable results due to contamination by sodium ethoxide. When the sodium was removed from the crucibles by vacuum distillation at 570° F., analyses of the scale were again inconsistent but X-ray powder photographs showed that most of it was $(Na_2O)_2 \cdot FeO$.

Mixtures of Na_2O and iron powder in an alumina boat were heated at 1110° F. for 2 hr. in an evacuated vitreosil-tube furnace. With mole ratios of Na_2O to iron greater than about 1.77, the molar ratio of the quantity of Na_2O originally in the mixture to the quantity of sodium vaporized was about 1.5, indicating the formation of $(Na_2O)_2 \cdot FeO$. When the original mole ratio was below 0.56, the amount of sodium vaporized indicated the formation of $Na_2O \cdot FeO$. Further studies suggested the possible formation also of nonstoichiometric mixed oxides of iron and sodium such as $Na_2O \cdot (FeO)_{1.6}$. The only stable mixed oxide in the presence of both sodium and iron seems to be $(Na_2O)_2 \cdot FeO$ and there is no evidence of one containing more sodium. Those containing more iron oxide are less stable in the presence of liquid sodium.

The compound $(Na_2O)_2 \cdot FeO$ can be reduced by distilled sodium, and its existence in the presence of liquid sodium is governed by the activity of the oxygen dissolved in the sodium. The stability of the compound also varies with temperature. In a closed system alternate formation and reduction of the compound could be brought about by thermal cycling and would aggravate solution erosion.

G. F. Comstock

A load of compressor valve caps, emerging from Thompson Products' modernized Homocarb furnace after carbon has been restored under Microcarb control. At left are valve stems of 0.40% carbon steel, ready for carbon restoration to a depth of 0.010" in a 2 hour cycle.

Decarb Correction with Microcarb® Saves 4 Ways

FOR THOMPSON PRODUCTS

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If you're now using Homocarb furnaces, Microcarb control can be added by your regular maintenance crews. To explore potential savings and conversion costs, there's an L&N field engineer ready to help you. Just phone the nearest L&N Office or write us direct at 4927 Stenton Ave., Phila. 44, Pa. For details about the workings of Microcarb control, request Catalog TD4-620(2).

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Welding Rod Coatings Without Ferromanganese

Digest of "Some Experiments on High-Manganese Arc Welding Rods", by D. R. Dhanbhoora, S. Visvanathan and S.N.A. Narayan, *Tisco*, Vol. 2, October 1955, p. 173-177.

LOW-CARBON ferromanganese is used in the coatings of arc welding electrodes as a deoxidizer and to promote fluidity in the slag and stabilization of the arc. Since this alloy is expensive in India, a substitute was sought by the research department of the Tata Iron and steel Co. High-carbon ferromanganese could not be used because it caused excessive spatter and fuming in welding. The use of the regular coating without ferromanganese on a steel wire containing 3.4% Mn also gave very disappointing results although the slag and metal deposited were almost the same composition as with standard electrodes.

Experiments were then carried out to develop a coating free from ferromanganese which would enable good welds to be made with this high-manganese wire. Variations in melting point and viscosity of the slag formed from the coating had little influence in obtaining a stable arc and a good weld. Some metal or alloy in the coating to increase its conductivity seemed to be required. When ferromolybdenum was used the arc characteristics were good but the welds were hard or lacked notch toughness. Iron powder was satisfactory in all respects. The best coating contained 16 parts silica, 10 parts manganese ore, 5 rutile, 4 mill scale, 4 bentonite and 2 of iron powder.

The weight of the coating was 60% of that of the steel core wire. The slag contained 40.4% SiO_2, 20.51% MnO, 3.5% Al_2O_3, 9% TiO_2, 9.55% FeO, 10.5% Fe_2O_3, 1.6% MgO, 1.66% alkali and 3% Fe. The metal in the slag was eliminated by using a higher welding current. The viscosity of the slag was high but the electrode performance of 3.4% Mn wire with the coating was good in large-scale trials. The weld metal contained only 0.35% Mn and 0.122% Si. Bend tests of single-bead deposits from such electrodes gave good results.

G. F. COMSTOCK

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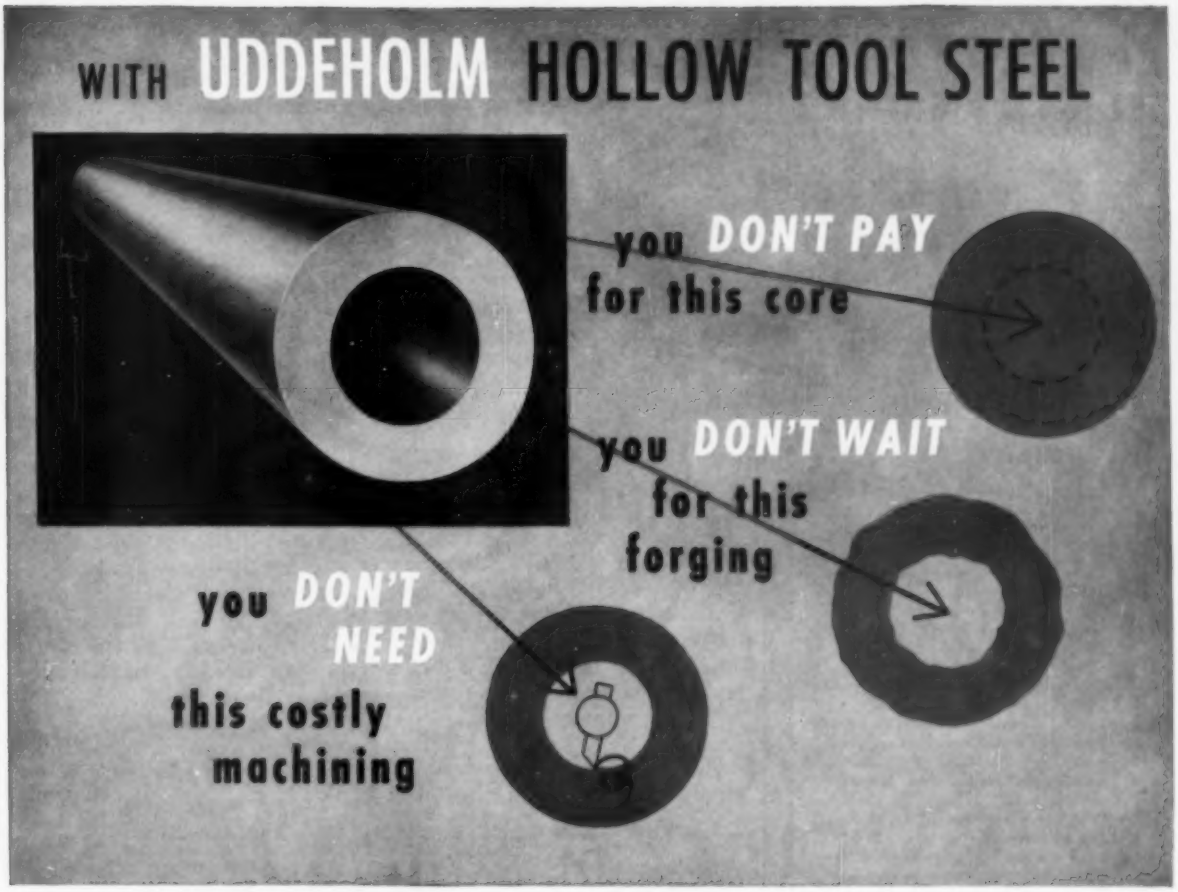

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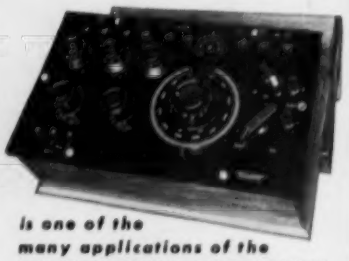

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Pressure Welding Stainless Steel Tubing

Digest of "Some Applications of Welding in the Development of Atomic Energy", by L. Rotherham, *British Welding Journal*, Vol. 2, September 1955, p. 377.

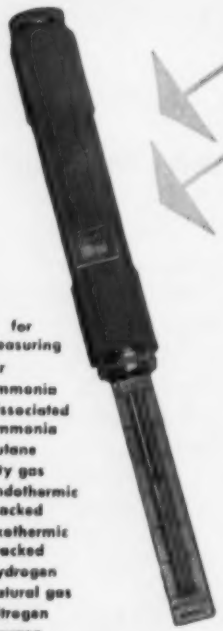
WELDED stainless steel tubing that has a smooth inside surface with no crevices is needed for piping in chemical processing plants and in atomic energy installations. An automatic machine capable of producing such tubing up to 3 in. in diameter was recently developed by the Industrial Group of the United Kingdom Atomic Energy Authority.

The joint is heated by an oxy-acetylene ring burner and the welding pressure cycle is controlled by cams. For 1-in. diameter tubing, the best pressure is 450 lb. for 25 sec., 150 lb. for 35 sec. and finally 450 lb. again. Such a cycle prevents thickening of the tubing adjacent to the weld and produces a ridge on the inside that is about 10 to 20% of the wall thickness. The outside reinforcement is ground off. Good welds with uniform corrosion can be produced with as much as 20% variation in pressure and 80% variation in time. Uniform corrosion means that the weld and tubing corrode at the same rate in boiling nitric acid.

Cleanliness of the mating surfaces is one of the most important factors. During the laboratory development of this process, the surfaces were turned, ground and then degreased, but such a lengthy procedure could not be used in economical large-scale production. They tried fine machining followed by degreasing but welded specimens had a band of unwelded metal on the inside of the pipe even when an argon or hydrogen atmosphere was used to back up the joint. Careful examination of the ends of the tubing showed that the degreasing had not been efficient and cutting lubricant had been left in the machined grooves. The difficulty was eliminated by making a fine cut dry after degreasing and carefully avoiding contamination from handling.

Burrs on the inside of the tubing also caused some welding difficulties and had to be removed carefully.

DAN WHITE



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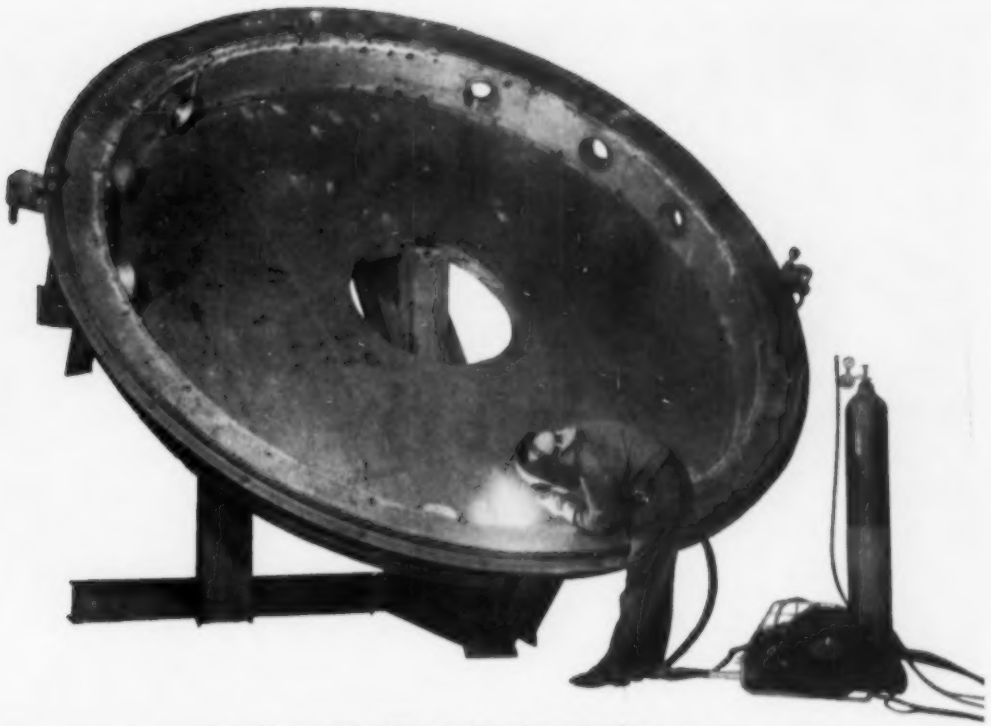
1. **Easy to clean.** No tools are needed for disassembly . . can be completely cleaned and reassembled in 2 minutes.
2. **Easy to read.** 6" scale gives extra visibility. Exclusive Waukee tabs identify in large red letters gas being measured. Eliminates mistakes.
3. **Built-in control valves.** Operators can easily see flow change.
4. **Easy to mount.** Can be panel mounted . . piping is simpler, installation costs less.

For additional information request bulletin #201.

for measuring
- air
- ammonia
- dissociated ammonia
- butane
- city gas
- endothermic cracked
- exothermic cracked
- hydrogen
- natural gas
- nitrogen
- oxygen
- propane

Waukee **ENGINEERING COMPANY**
403 E. Michigan Street, Milwaukee, Wis.



a complete **AIRCOMATIC** "package" . . . from recommendation to results

Aircomatic welding is an inert-gas, shielded arc process using a a consumable wire electrode. The basic unit, manual or automatic, designed and manufactured by Airco, includes the welding head, carriage assembly for wire drive and control equipment, cables, hoses, and flexible wire casing.

The consumable wire electrode is produced to rigid Airco specifications as to purity, cast, and metallurgical content. Normally supplied on expendable spools, Aircomatic wire is available in aluminum, steel, stainless steel, nickel, titanium, copper, and copper base alloys.

Airco shielding gases include both helium and argon, produced by Airco, or mixtures thereof for particular requirements. Pure carbon dioxide gas is also available from Airco for use as a shielding medium where applicable.

Aircomatic is a direct-current welding process. A complete line of Airco motor-generator and rectifier type welders are designed for Aircomatic characteristics – the latest of which is a new constant potential 800 amp ACV welder.

The Aircomatic process was invented, designed, developed, and licensed by Airco. Airco's eight years of experience have given the metal working industry an inert-gas process that welds all kinds of metals – adding speed, economy and versatility to every suitable application.

An Airco Representative can give you a completely unbiased opinion as to how Aircomatic can best be employed – because – Airco is a leading manufacturer-supplier of all types of oxyacetylene, metallic arc and inert-gas shielded welding and flame cutting processes, their controls, supplies, and accessories.

Other Airco inert-gas welding processes include Aircospot and Heliwelding. Write today for details.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

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A division of Air Reduction Company, Incorporated, New York 17, N. Y.

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Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** – industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** – carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** – medical gases and hospital equipment • **NATIONAL CARBIDE** – pipeline acetylene and calcium carbide • **COLTON** – polyvinyl acetates, alcohols, and other synthetic resins.

Photo courtesy The Alliance Drop Forging Co.

●Youngstown Hot Rolled Alloy Bars assure uniform response in our customers operations because such uniformity starts at the Ore Mines. At every operation, in Youngstown's completely integrated steel manufacturing facilities, rigid quality controls make certain that uniform chemistry, physical properties and dimensions are furnished.

SPECIFY

Youngstown

Hot Rolled QUALITY YOUNGSTOWN SERVICE Alloy Bars

THE YOUNGSTOWN SHEET AND TUBE COMPANY Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices: Youngstown, Ohio - District Sales Offices in Principal Cities

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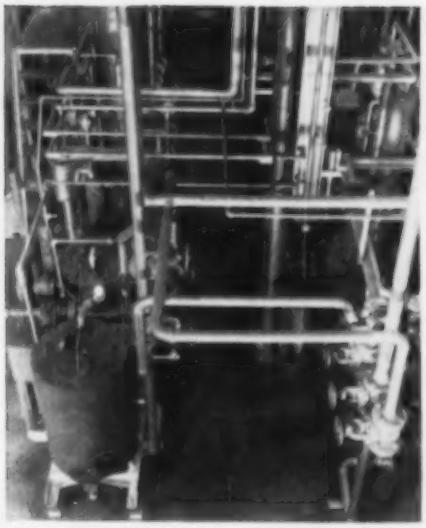
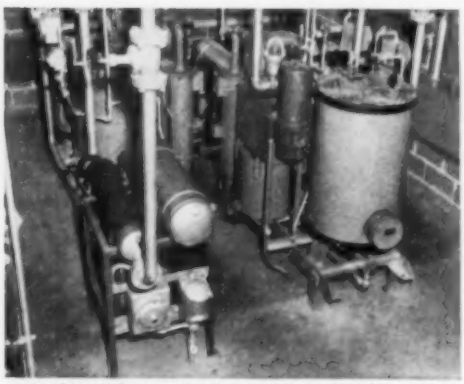


Two BWC-250 Lectrodryers work in the gas purifying room at Carboloy's Detroit plant.

Because moisture would impair quality, Carboloy DRY hydrogen to −80° F.

Lectrodryers DRY the hydrogen used in sintering and brazing operations*



At their Edmore, Michigan plant they have two BWC-250 Lectrodryers in the power plant.

MOISTURE in the hydrogen used to fire sintering furnaces would break down, freeing oxygen. This would form oxides, causing inclusions in carbides. It would consume the aluminum intended for alloying in magnets. Carboloy, Department of General Electric Company, avoids those hazards by removing every trace of moisture to dewpoints below −80°F.

Carboloy's cemented carbides, Hevimet and Alnico permanent magnets are all produced in hydrogen-fed furnaces. You see one here. As evidence of the extensiveness of these operations, the Detroit plant alone is capable of producing a million cubic feet of hydrogen a week. Lectrodryers can DRY that volume, staying on-stream continuously, without interruption.

Metallurgical operations elsewhere similarly employ gases dried by Lectrodryers. Your manufacturer of controlled atmosphere generators can advise you on their use, where DRY gases are indicated.

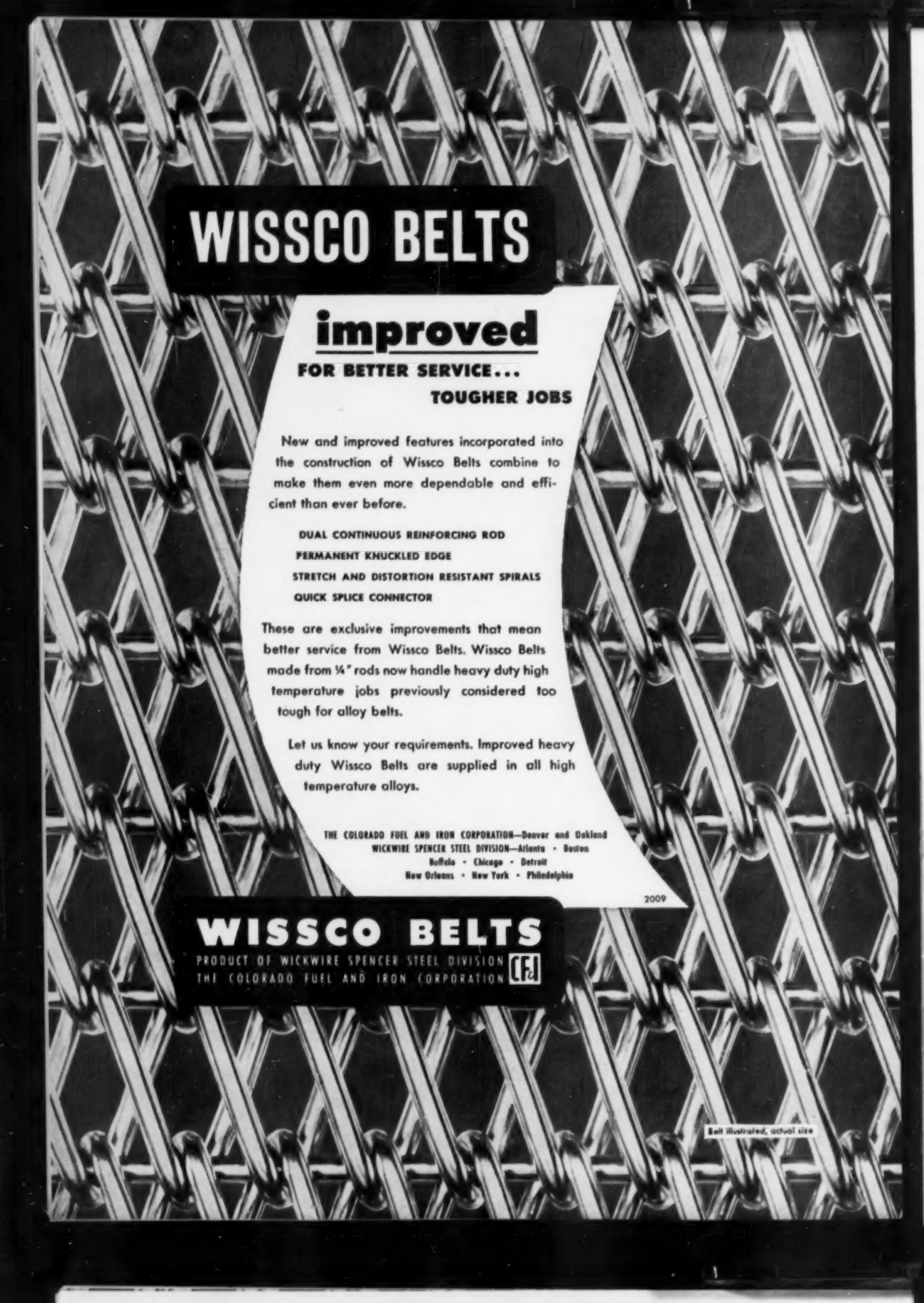
Pittsburgh Lectrodryer Company, 317 32nd Street, Pittsburgh 30, Pa. (a McGraw Electric Company Division).

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubeix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubeix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.


WISSCO BELTS
improved
FOR BETTER SERVICE...
TOUGHER JOBS
New and improved features incorporated into the construction of Wissco Belts combine to make them even more dependable and efficient than ever before.
DUAL CONTINUOUS REINFORCING ROD
PERMANENT KNUCKLED EDGE
STRETCH AND DISTORTION RESISTANT SPIRALS
QUICK SPLICE CONNECTOR
These are exclusive improvements that mean better service from Wissco Belts. Wissco Belts made from ¼" rods now handle heavy duty high temperature jobs previously considered too tough for alloy belts.
Let us know your requirements. Improved heavy duty Wissco Belts are supplied in all high temperature alloys.
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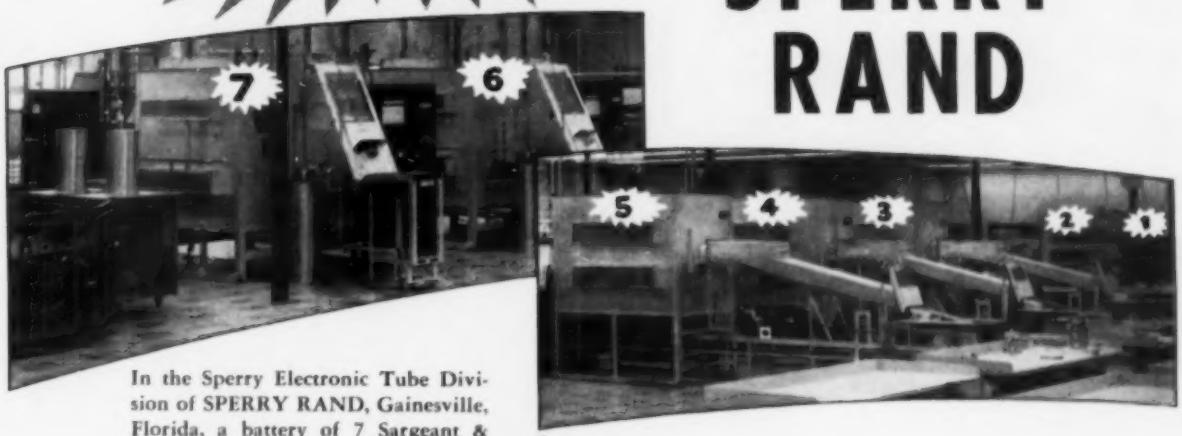
2009
WISSCO BELTS
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION
CFI
Belt illustrated, actual size

7 Furnaces at SPERRY RAND



In the Sperry Electronic Tube Division of SPERRY RAND, Gainesville, Florida, a battery of 7 Sargeant & Wilbur furnaces perform faithfully and economically, aiding in the production of klystron tubes.

● Five S&W Conveyor Furnaces with 15" belts are used for silver and copper brazing of klystron tube components, as well as for degassifying and oxidizing.

Two S&W Pusher Furnaces are used primarily for brazing operations.

Atmosphere is dissociated ammonia, produced from two 2,000 CFH S&W Ammonia Dissociators.

Purging atmosphere is supplied by a 1500 CFH Forming Gas Generator. This atmosphere is dried by an automatic, activated alumina dryer.

Write today for literature—and state your problem. Our staff of engineers is ready to advise without obligation.

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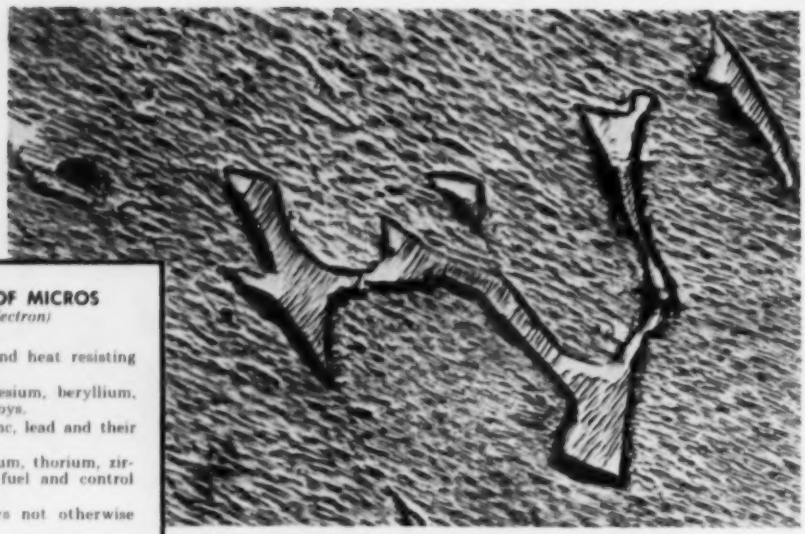
Complete Line of Electric and Fuel Fired Heat Treating Equipment • Furnaces • Generators • Ammonia Dissociators Gas Conditioning Equipment • Accessories

11th Metallographic Exhibit



CLASSIFICATION OF MICROS
(Optical and Electron)

Class 1. Irons and steels.
Class 2. Stainless steels and heat resisting alloys.
Class 3. Aluminum, magnesium, beryllium, titanium and their alloys.
Class 4. Copper, nickel, zinc, lead and their alloys.
Class 5. Uranium, plutonium, thorium, zirconium and reactor fuel and control elements.
Class 6. Metals and alloys not otherwise classified.
Class 7. Series showing transitions or changes during processing.
Class 8. Welds and other joining methods.
Class 9. Surface coatings and surface phenomena.
Class 10. Results by unconventional techniques (other than electron micrographs)
Class 11. Slags, inclusions, refractories, cermets and aggregates
Class 12. Color prints in any of the above classes (no transparencies accepted)

Entries are invited in the 11th ASM Metallographic Exhibit, to be held at the National Metal Exposition in Cleveland, Oct. 6 through 12, 1956.

RULES FOR ENTRANTS

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints should be mounted on stiff cardboard; maximum dimensions 14 by 18 in. (35 by 45 cm.) Heavy, solid frames are unacceptable. Entries should carry a label on the *face* of the mount giving:

Classification of entry
Material, etchant, magnification
Any special information as desired

The name, company affiliation and postal address of the exhibitor should be placed on the *back* of the mount.

Entrants living outside the U. S. A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection".

Exhibits must be delivered before Oct. 1, 1956, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

ASM Metallographic Exhibit
7301 Euclid Ave.
Cleveland 3, Ohio

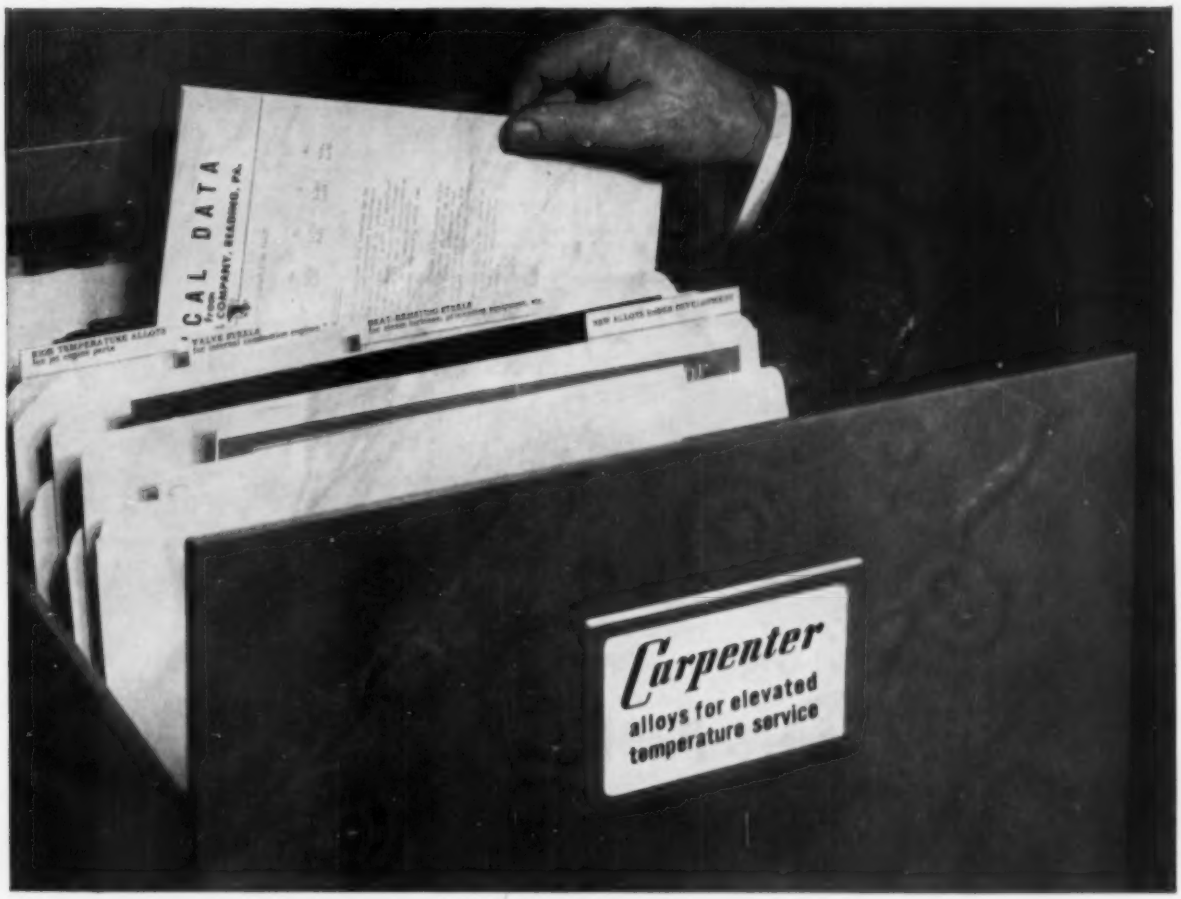
AWARDS AND OTHER INFORMATION

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $100, will also be awarded the exhibitor whose work is judged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's national headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1957 if so desired.

38TH NATIONAL METAL CONGRESS AND EXPOSITION

CLEVELAND, OHIO **OCTOBER 6 to 12, 1956**



Discover how these ELEVATED TEMPERATURE ALLOYS can give you

√ Improved Forgeability √ Greater Uniformity √ Cleaner Steels

Exciting possibilities for improvement are ahead when you look into the line of Carpenter alloys for parts or products in elevated temperature service. Here is a line of high temperature and heat-resisting alloys produced in a specialty mill. Only a true specialty mill can produce so well these very difficult-to-make alloys.

Here, too, is a combination of unusual advantages not normally found in this type of alloys. For example, Carpenter pioneered the addition of rare earth elements to the analyses of certain grades to give you improved forgeability. And Carpenter's unsurpassed, meticulous quality controls, assure you steels with greater uniformity and extra cleanness to meet the strictest inspection requirements.

Whether you work with one of our present elevated temperature alloys, or a steel produced specifically for your own application, you'll find that Carpenter's wealth of fabricating and working information will help you substantially reduce production costs and get better parts.

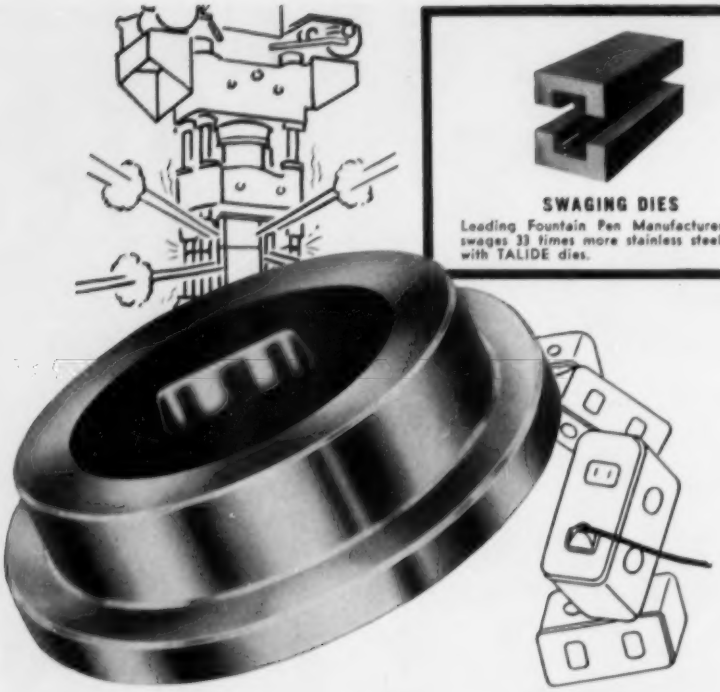
Outline your plans or problems to your Carpenter Representative or write direct. You'll get the kind of help that pays off with definite improvements. *The Carpenter Steel Co., 133 W. Bern St., Reading, Pa.*

Specify Carpenter alloys for elevated temperature service and get these three big advantages . . .

Improved Forgeability
Greater Uniformity
Cleaner Steel

Carpenter STEEL

Improved Alloys for Elevated Temperature Service



SWAGING DIES

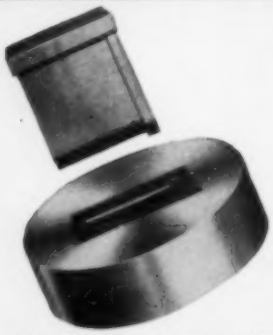
Leading Fountain Pen Manufacturer cold swages 33 times more stainless steel parts with TALIDE dies.

HEADING AND EXTRUSION DIES

Cold-heading 1/4". C-1008 steel rivets, TALIDE dies produced 11,200,000 pieces, other carbide dies only 3,500,000.

CURLING ROLLERS

TALIDE Curling Rolls last 65 times longer than steel rolls on beverage can forming operation.



BLANKING AND FORMING DIES

70 times more paper discs blanked out with TALIDE — over hard alloy die.

SHEET METAL DIES

137,000 hi-alloy steel Pressure Vessels drawn with TALIDE, against only 7,900 with steel dies previously used.

POWDERED METALLURGY DIES

Compacting highly abrasive chemical powders, TALIDE Pill dies last 4 months, steel dies were out in 8 hours.

25,680,000 PARTS PRODUCED with ONE TALIDE DIE

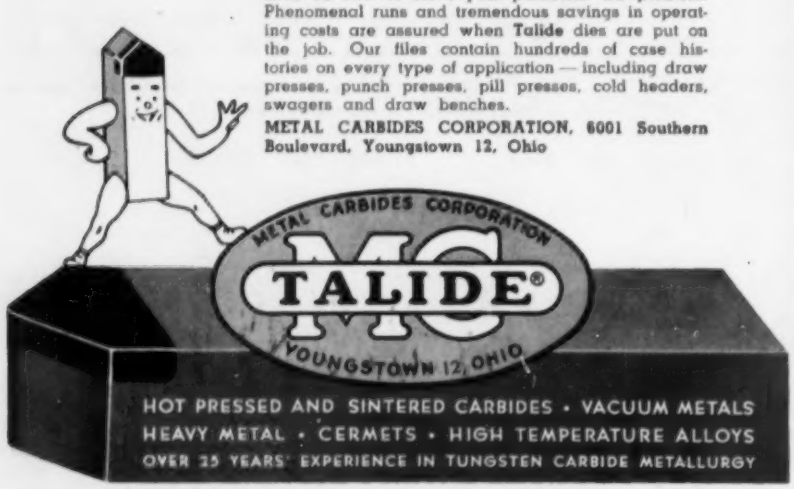
A large electrical equipment manufacturer was having difficulty maintaining production of electrical outlet boxes. Die costs were high, downtime and scrap excessive. It was necessary to remove and repolish the hi-carbon, hi-chrome die every 60,000 pieces. Total production secured from each steel die averaged 700,000 pieces.

After an initial survey, our die engineers designed and installed a **Talide** die using **Grade C-88.** Operation is performed on a 75-ton double action Bliss press. Original die was put in operation 3 years ago and is still going strong, having been removed only once for repolishing — after drawing 15,000,000 pieces!

Total production obtained to date has reached the astounding figure of 25,680,000 outlet boxes — 36 times more production than when using a steel die. The Talide die costs $1,125.00 compared to $500.00 for each steel die. Savings in die cost alone has amounted to over $18,000.00 over the past 3 years, with substantial additional savings realized in increased production. Downtime, repolishing cost and scrap expense were completely eliminated.

Call in a **Talide** sales engineer for recommendations on how to solve your particular die problem. Phenomenal runs and tremendous savings in operating costs are assured when **Talide** dies are put on the job. Our files contain hundreds of case histories on every type of application — including draw presses, punch presses, pill presses, cold headers, swagers and draw benches.

METAL CARBIDES CORPORATION, 6001 Southern Boulevard, Youngstown 12, Ohio


METAL CARBIDES CORPORATION
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TALIDE®
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HOT PRESSED AND SINTERED CARBIDES • VACUUM METALS
HEAVY METAL • CERMETS • HIGH TEMPERATURE ALLOYS
OVER 35 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY

10 to 100% faster pumping– with Stokes Ring-Jet diffusion pumps

Major advance in diffusion pump design increases capacities, shortens vacuum pumping cycles, permits operation against higher forepressures.

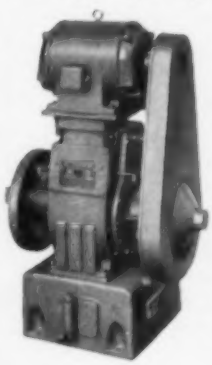
A COMPLETELY DIFFERENT design concept makes it possible for Stokes Ring-Jet diffusion and booster pumps to provide high vacuum pumping performance never before possible. Instead of a single jet cone, these pumps have a ring of jets. This construction increases cross-sectional area of the air path . . . retains short distance to the condensing surface.

The result: for a given size of pump, the Ring-Jet design increases pumping capacity from 10% to more than 100%. Pumping speeds are substantially higher in the critical ranges. A 6-inch Stokes Ring-Jet booster can evacuate 760 cfm at 50 microns, 1400 cfm at 15 microns. The pump can also operate against higher forepressures. At normal heat input, the 6-inch booster is rated at 2.4 mm.; the 16-inch diffusion pump, 0.35 mm.

This increased efficiency cuts pumping cycles, permits use of smaller mechanical roughing pumps. It puts added value into many types of vacuum processing equipment . . . such as metallizers, vacuum furnaces and exhausting systems. Both diffusion and booster pumps are available in a range of sizes from 4 to 16 inches. For specifications, or for a consultation on your high vacuum application, call your nearest Stokes office. F. J. Stokes Machine Company, *Vacuum Pump Division*, 5508 Tabor Road, Philadelphia 20, Pa.

STOKES

MICROVAC mechanical pumps for high capacity, low maintenance

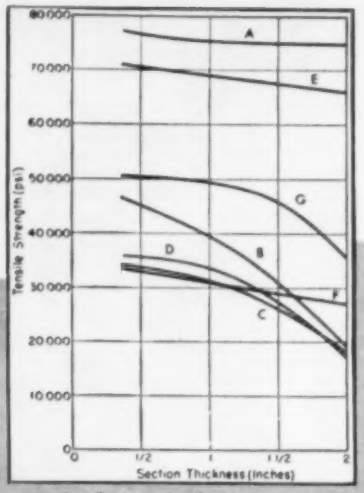


Ideal for use as roughing pumps, or as sole soutces of vacuum in applications not requiting diffusion pump performance. New design features assure fast pumping, high capacity, efficiency over wide pressure range. Trouble-free operation is provided by fail-safe design, intake screen filters, double-spring exhaust valves. Write for Catalog 751 for complete information.

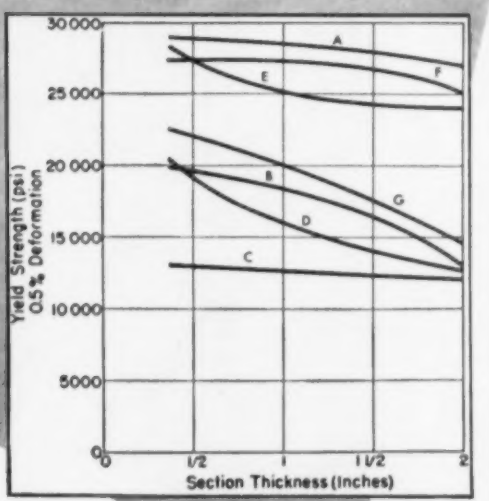
Here's proof....

that you can use lighter sections, have greater strength, improve your product, save money

with AMPCO* Metal



Tensile strengths of various non-ferrous metals vs. section thickness



Yield strengths of various non-ferrous metals vs. section thickness

Examine these charts carefully — they tell a story that can save you money and put extra life and dependability into your product.

Look, for instance, how other non-ferrous metals show a sharp decrease in mechanical values as casting cross-sections increase. Ampco remains practically constant — you require less metal.

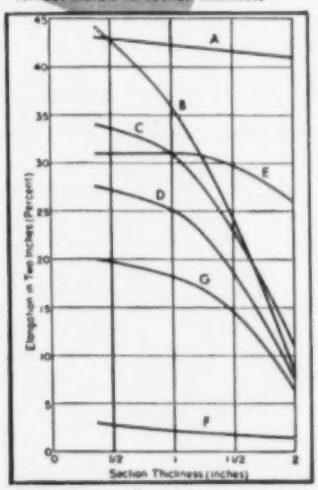
Note Ampco's unusually high tensile and yield strengths compared with conventional bronzes — you use lighter sections to do a better job. And Ampco Metal weighs 10 to 15 percent less than other bronzes — so you can make important weight reductions

Fact is, Ampco Metal's high strength-to-weight ratios can mean real savings for you — savings in material and money. Consult your nearby Ampco field engineer for full information or write us.

CHART REFERENCE

- A. Ampco Metal
- B. Tin Bronze (88-8-4)
- C. Red Brass
- D. Tin Bronze (85-5-5-5)
- E. Manganese Bronze
- F. Aluminum Alloy
- G. Silicon Bronze

Charts courtesy Materials & Methods and Westinghouse Electric Corp



Elongations (2") of various non-ferrous metals vs. section thickness

AMPCO®

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept MP-4, Milwaukee 46, Wisconsin

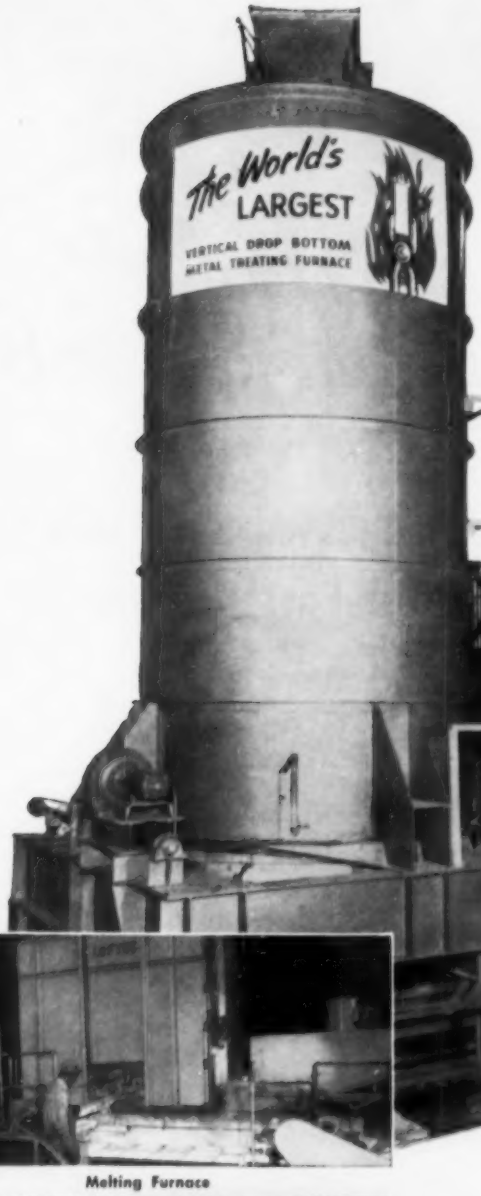
West Coast Plant: BURBANK, CALIFORNIA

*Reg U S Pat Off

9-43

LOFTUS *Aluminum* FURNACES

- Soaking Pits
- Melting and Holding Furnaces
- Heat Treating Furnaces
- Induction Heating Furnaces



Drop Bottom Furnace

Melting Furnace

Soaking Pits

As designers and constructors of the most modern, efficient furnaces for the aluminum industry, Loftus recently completed the world's largest Vertical Travel Type Drop Bottom Metal Treating Furnace. Commenting on this ultra-modern installation, our customer says: "Loftus can be proud of pioneering this type of furnace for the metal treating industry." Whatever your furnace requirements, you can depend on Loftus for the best possible heating at the lowest possible cost.

Write today for complete details

Loftus ENGINEERING CORPORATION
Designers and Builders of Industrial Furnaces
610 Smithfield Street, Pittsburgh 22, Pennsylvania

56.17.2

1,370,000 Miles of Steel Strip per year

. . . processed with SELAS One-Pass Heating

Enough steel strip to go around the world 55 times, is processed per year in Selas one-pass Gradiation furnace installations throughout the steel industry.

The Selas direct-fired heating principle is used in a number of continuous strip applications, including:

Bright annealing of steel . . . stainless steel annealing . . . tin reflow . . . galvanizing-annealing . . . preheat for galvanizing . . . preheat for annealing . . . bluing . . . special coatings . . . brass annealing.

In all these operations, radiant gas heat, precisely applied across the strip width, increases heating speed and produces unsurpassed uniformity in product quality.

- Compact single-vertical-pass design saves valuable floor space . . . avoids rolls in heated section and accompanying maintenance and product quality difficulties.
- Elimination of externally-prepared atmosphere in heating section reduces operating costs.
- Precise thermal control assures reproducible uniformity, regardless of gauge variations.

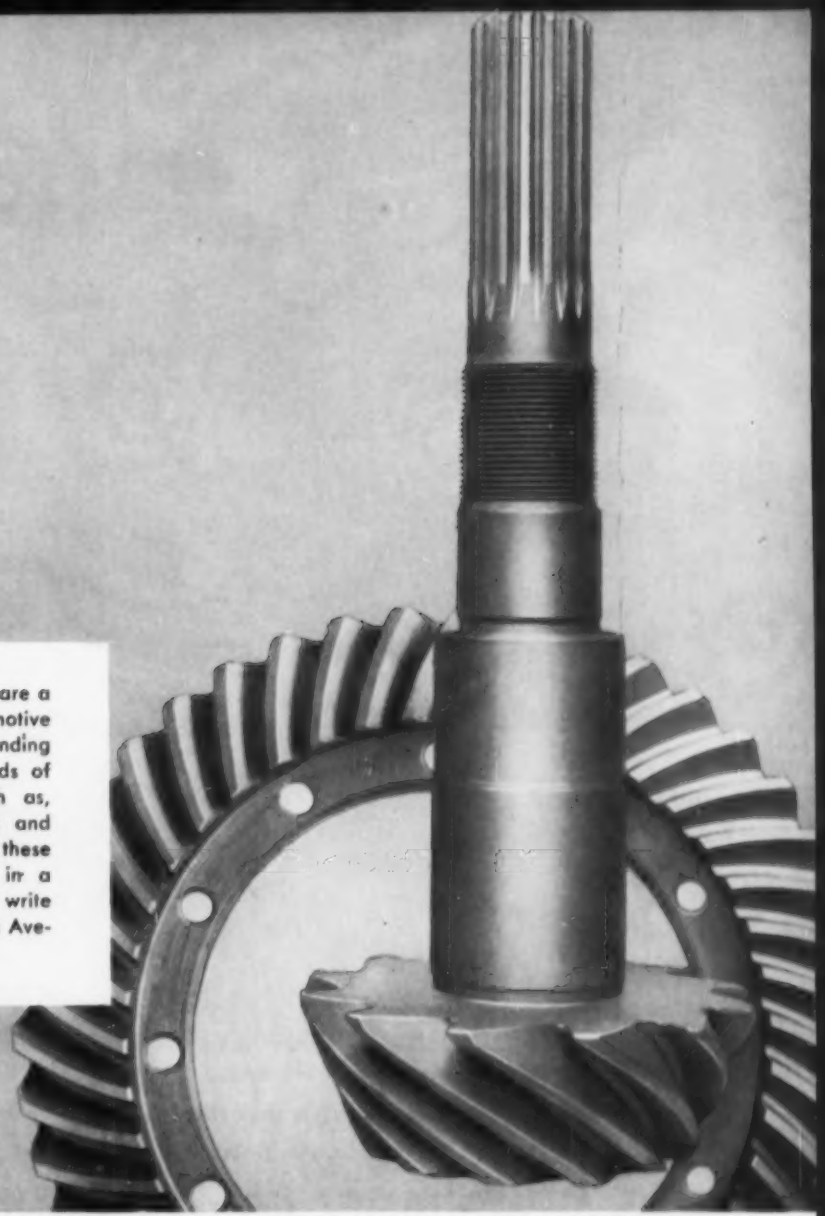
The same benefits are also being achieved in continuous annealing of nonferrous metals.

Our engineers will be glad to discuss how Selas Gradiation methods can be tailored to your strip-heating needs. Address Dept. 64.

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers
DEVELOPMENT • DESIGN • CONSTRUCTION

"IT'S BETTER IF IT CONTAINS MOLY"



Moly carburizing steels with 0.5% Mo are a natural for components like this automotive ring-gear and pinion. They have outstanding properties that suit them to the demands of gearing and similar applications, such as, superior case hardness, low distortion and good machinability. Many features of these new carburizing steels are discussed in a recent technical article. For a reprint, write Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y., Dept. 5.

Molybdenum Carburizing Steels

MOLYBDENUM OFFERS THE ECONOMICAL KEY TO PERFORMANCE

Over the years, molybdenum carburizing steels have proved their merits in scores of applications and at every level of production.

Design engineers know moly steels for their uniform hardenability, toughness and wear resistance.

Production men know that moly steels are easy to heat treat, easy to machine.

Management knows that moly steels mean economy in fabrication, high performance in a wide range of end products.

Standard molybdenum carburizing steels are widely available. Higher moly analyses may be ordered in heat lots from a number of leading suppliers.

CLIMAX MOLYBDENUM

SODIUM
metallic

talk about reducing!

—and you'll talk about Ethyl's high purity sodium. Ethyl Corporation, working closely with organizations in the chemical and metallurgical fields, offers metallic sodium ideally suited in form and purity to the needs of those interested in reducing metal salts or in other reactions with organic and inorganic compounds.

Available in tank cars, and cast solid in drums, Ethyl can furnish sodium specially filtered and handled under argon, out of contact with nitrogen or oxygen.

Top physical properties of the refractory metals demand the finest sodium. Numerous chemical reactions may benefit greatly from the use of this high purity sodium.

The Ethyl Research Laboratories have developed improved techniques for the analysis of sodium for oxides and other impurities. We would be happy to supply high purity sodium for your work and to give technical service on sodium analysis where desired.

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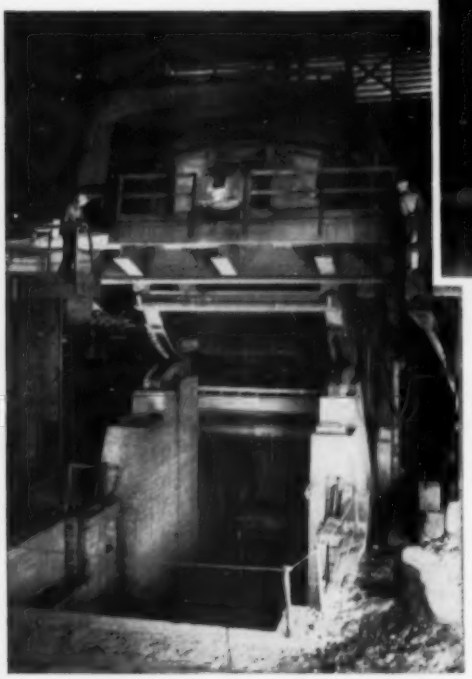
Heroult
ELECTRIC MELTING FURNACES

TOPS FOR PRODUCTION OF HIGH GRADE STAINLESS, ALLOY AND RIMMING STEELS



This free Catalog will help you determine how Heroult Electric Furnaces can improve your operation . . . and enable you to make better quality steels. Tells you where and when an electric furnace is desirable. Gives furnace types, sizes, capacities and ratings. For your free copy, just contact the office nearest you, or write direct to Pittsburgh.

You can make better quality steel faster with the Heroult!

If you're faced with the need for higher production . . . and a higher grade of steel . . . in order to improve the competitive position of your mill, the modern Heroult electric furnace can prove a mighty profitable investment for you.

Embodying the latest in mechanical and electrical equipment, these widely accepted furnaces are noted for their efficient performance and low operating and maintenance costs.

Available in sizes of shell diameter ranging from 7'0" up to 24'6", and with rated charge capacity of from 8000 lbs. up to 400,000 lbs., they are equipped with removable roofs to permit top charging. Both gantry and swing-type roof-removing mechanisms are available. Door-charging furnaces and furnaces of special design, including units equipped with austenitic steel bottoms to permit inductor stirring, can be supplied.

We welcome an opportunity to help you select and install the Heroult best suited to your needs. Please remember, however, that because the Heroult is a precision-engineered unit . . . made to order . . . to fit your particular requirements, it is advisable to anticipate your future needs as far in advance as possible. *The Heroult we make and install for you will be the finest electric furnace that money can buy!*

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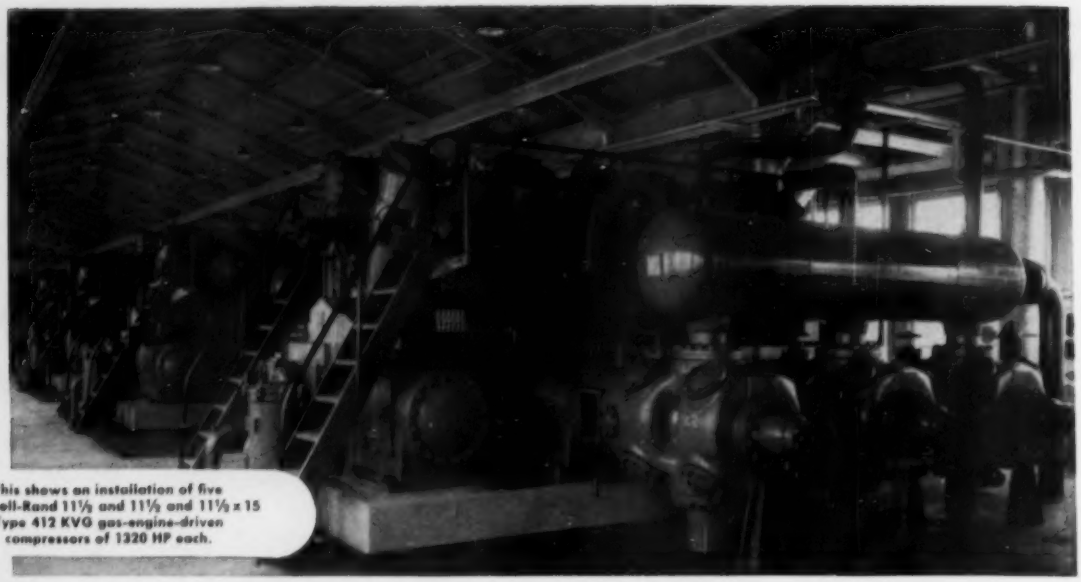
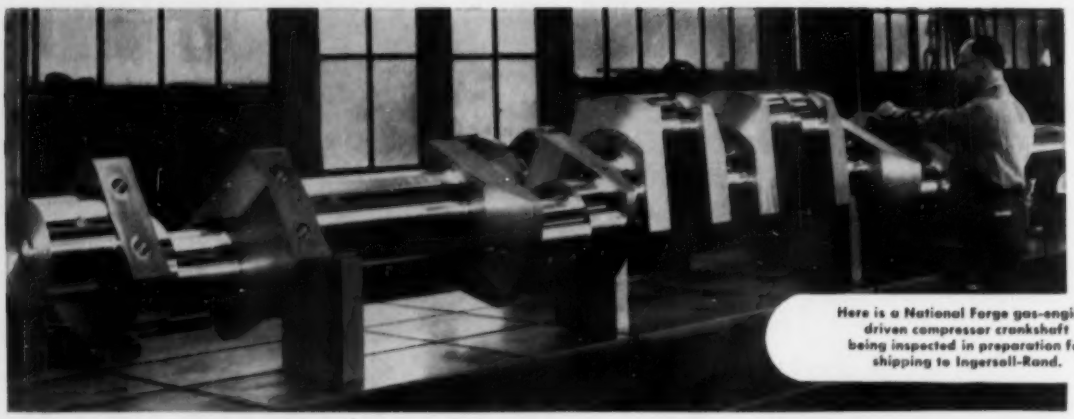
UNITED STATES STEEL



This shows an installation of five Ingersoll-Rand 11½ and 11½ and 11½ x 15 Type 412 KVG gas-engine-driven compressors of 1320 HP each.



Here is a National Forge gas-engine-driven compressor crankshaft being inspected in preparation for shipping to Ingersoll-Rand.

INGERSOLL-RAND USE NATIONAL FORGE CRANKSHAFTS IN THEIR POWERFUL COMPRESSORS

It takes a lot of muscle to move gases over the long distances of America's pipe line network and these large Ingersoll-Rand gas-engine compressors have what it takes. Each component that goes into them must perform its function with complete reliability.

National Forge takes pride in being an Ingersoll-Rand supplier. The crankshaft shown here originated with National Forge basic electric steel and was turned out in successive steps of forging, rough machining, heat treating and finish machining. In every step of the process, continuous checks were made to maintain the close control necessary to final performance.

Your forgings receive the same meticulous care when they are National Forged and you may be sure that you receive the finest quality obtainable.

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PRODUCES BETTER STEEL FORGINGS AND MACHINE WORK

IRVINE, WARREN COUNTY, PENNSYLVANIA

Sperry

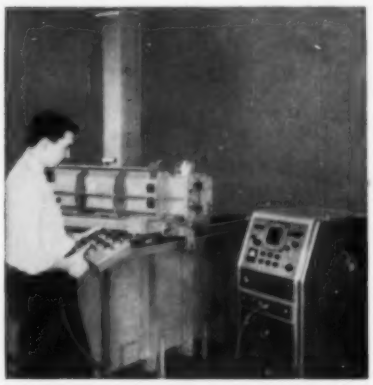
ultrasonic inspection news

SIMAC INSPECTION SYSTEMS NOW AVAILABLE FOR GENERAL INDUSTRY USE

Through the development of standard-unit ultrasonic inspection equipment and auxiliary components, Sperry makes it possible to assemble automatic or semi-automatic SIMAC systems at greatly reduced costs. The basic unit is the Type UW Reflectoscope which can be combined with auxiliary test equipment to meet individual flaw detection requirements. Shown above, the UW Reflectoscope is being used to inspect an immersed aircraft forging which has contours requiring the use of a precision (PH) search unit positioner in order to control the direction of the ultrasonic beam projected into the part.

For contact or immersion testing:

The flexibility of the UW Reflectoscope enables it to handle a vast range of inspection problems, both contact and immersed. It is designed to be operated manually, semi-automatically (as shown at the left) and fully automatically in conjunction with other Sperry-engineered equipment.



The UW's wide range of 9 operating frequencies (from 200 kc to 25 mc) permits driving through coarse material or long distances using the lower frequencies, while the high frequency range can locate the smallest defects.

Immersion tanks have been standardized in several sizes to meet different inspection requirements and are also built to specification.

Automatic Signaling and Recording

The UWA Monitor is designed to operate in conjunction with the UW Reflectoscope to provide automatic signaling and recording of defects. Set up for a specific test, it interprets signals from the UW Reflectoscope and passes on the evaluated information to the operator in the form of signal lights and alarms. Permanent tape records can be made as well as actual automatic marking of the part under test.

Two additional displays of test information:

The UWB attachment supplements the Monitor with a cross-section view of the material being tested, displayed on a 12-inch CRT screen with long image persistence. Two meter indicators measure the amplitude of reflected signals.

To keep posted on latest developments in the profitable use of ultrasonic inspection, send for your copy of our Ultrasonic Inspection News Letter.

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For complete information plus list of sales offices, see our catalog in your company's copy of Sweet's 1956 Plant Engineering File.

Sperry Products, Inc. MP-4
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☐ Send me detailed Reflectoscope information.

☐ Send me the Ultrasonic News Letter.

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Company _____

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ZIRCONIUM-MAGNESIUM MASTER ALLOY

INCREASED STRENGTH

AT ELEVATED TEMPERATURES

Light magnesium alloy castings will gain high impact strength at elevated temperatures when Zirconium is added. TAM's Master Alloy provides a most efficient method. Notch bars are readily soluble in production heats. Recoveries are high.

In addition to greater impact strength at elevated temperatures, a tough fine grain structure is produced . . . relatively free of contamination. It is readily castable or extrudable, with minimum microporosity or microshrinkage. It resists corrosion.

Foundrymen prefer TAM Master Alloy for its ease of handling and storing as well as its freedom from obnoxious fuming.

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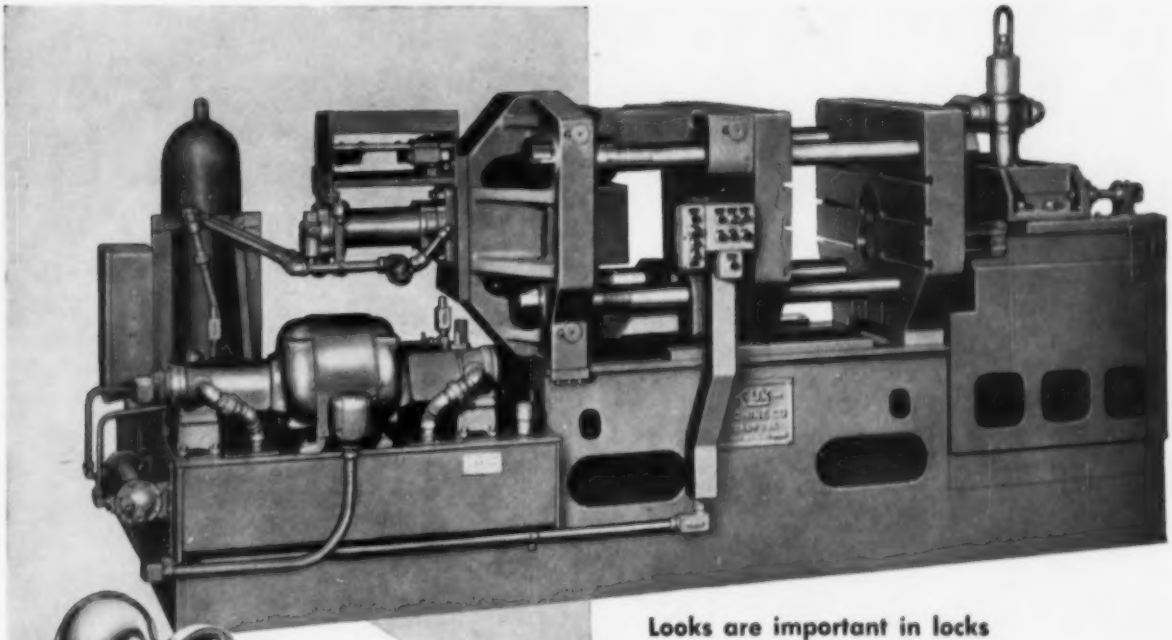


Looks are important in locks

SO...KWIKSET CHOSE

KUX

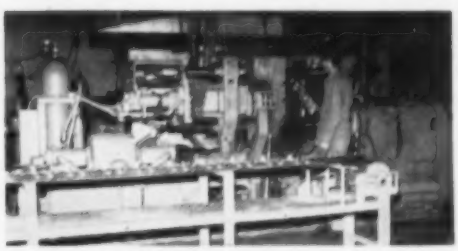
DIE CASTING MACHINES

to get hardware finish quality

Locks must have eye appeal to sell . . . they must be economically priced . . . easy to install . . . and offer long trouble-free service. Kwikset Locks, Inc., Anaheim, Calif., has achieved all these things which accounts for the more than 25,000,000 of its "400 line" of locksets now in *unconditionally guaranteed* service.

KUX die casting machines have played an important role in this remarkable record. Many of the individual parts that make up the three easy-to-install precision-matched components of a "400" lockset are die cast. KUX machines are used because Kwikset knows a hardware finish quality is obtained on every gate cast. A dense hardware finish quality on a close tolerance casting reduces costs throughout the manufacturing and assembly processes and puts Kwikset in a fine competitive position.

KUX produces a full range of modern die casting machines that require only the touch of an electric button to put them automatically through a complete casting cycle at high production speeds. KUX engineers will be glad to show you how die casting machines can serve you. Or, write for an illustrated catalog.



The New MODEL BH-30

This new, more powerful, higher speed model shown above, is a hydraulically operated gooseneck plunger type of machine for production of zinc, lead or tin die castings. It is one of the many KUX machines in operation at the Kwikset plant.

KUX MACHINE CO.
6725 NORTH RIDGE AVENUE
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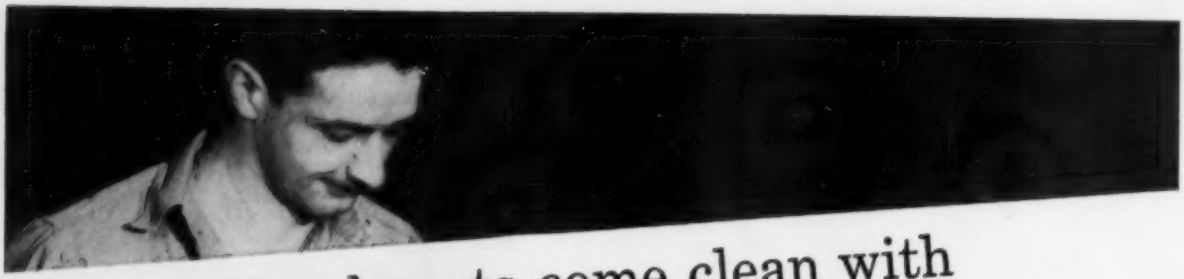

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NIALK TRICHLORethylene is one of the most efficient of all metal cleaning and degreasing agents.

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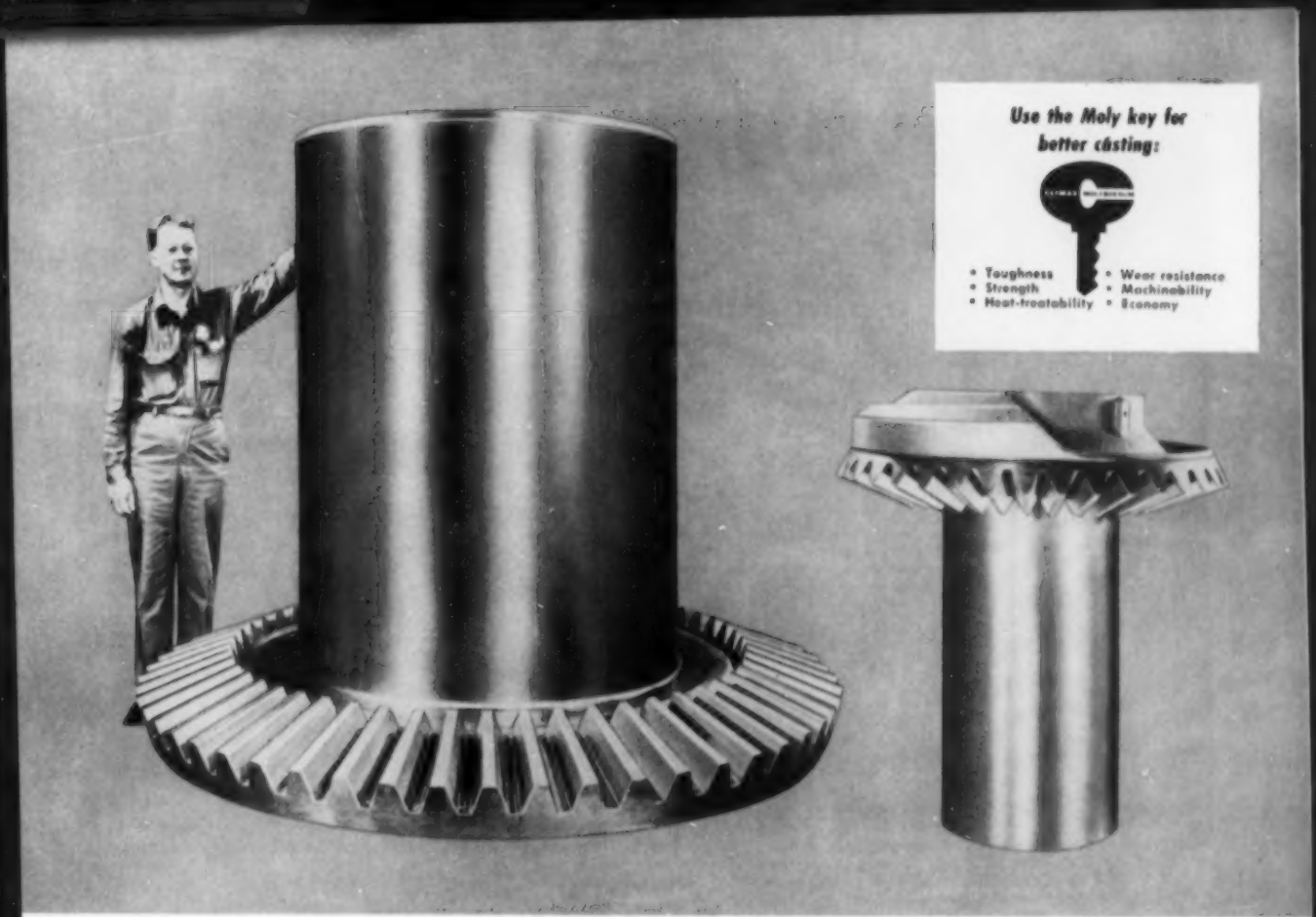
Send for free illustrated booklet, NIALK TRICHLORethylene, *containing valuable data on the use and handling of this chemical.*

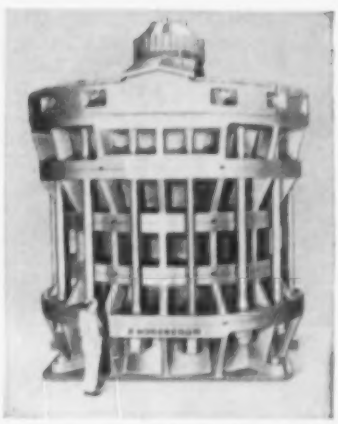


Heavy duty ore crushing machinery is subjected to severe operating conditions. To meet these strenuous requirements the gears shown are made from heat treated low-alloy manganese-*Molybdenum* steel castings. At left: a Symons Gyratory Crusher gear; right: a Symons Cone Crusher gear. Built by Nordberg Mfg. Co.

Cast Manganese Moly Steel contributes strength and toughness to Crushers built by Nordberg

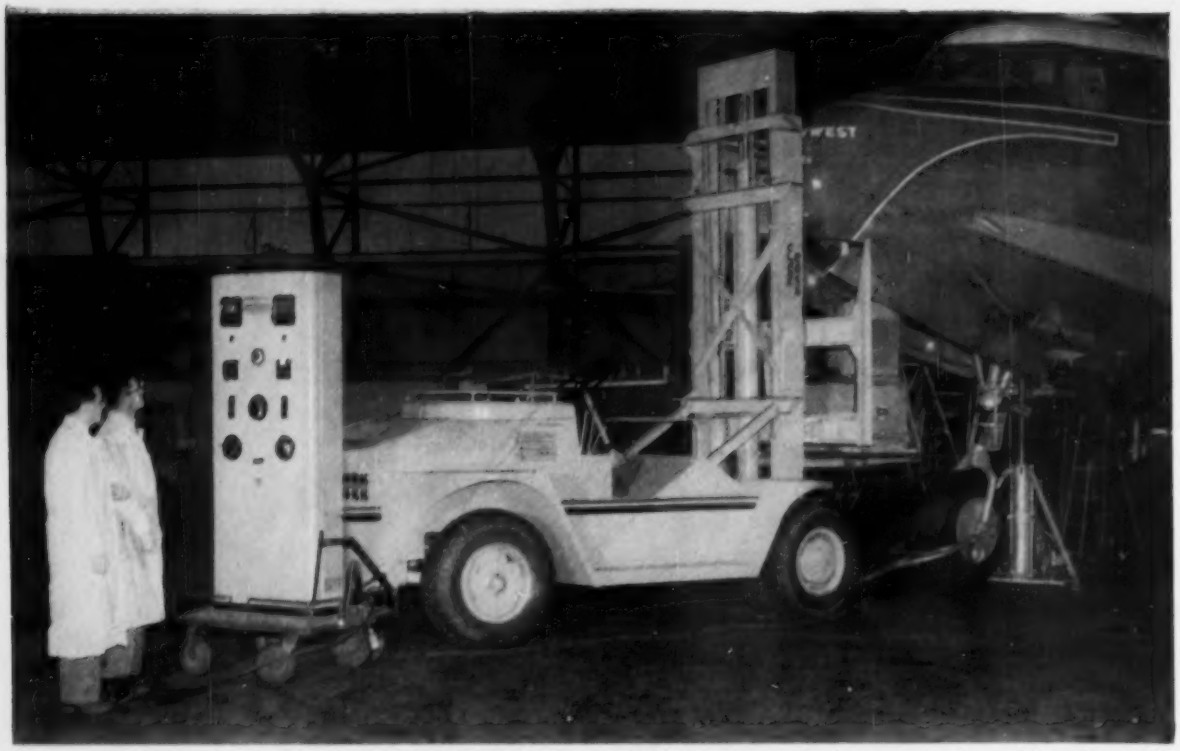
"Where high strength and toughness are prime considerations," says Howard Zoerb, Consulting Engineer of the Nordberg Crusher Division, "molybdenum bearing steels are specified. This is true of the heavy duty parts of Symons® Crushers, built by Nordberg. These steels have contributed to the Nordberg reputation as producers of dependable, heavy duty crushing machinery."

Technical assistance is available to foundries on alloying problems. Please address inquiries on your foundry letterhead to: Climax Molybdenum Company, Department 5, 500 Fifth Avenue, New York 36, New York.



The Symons Cone Crusher is a product of Nordberg Manufacturing Company.

CLIMAX MOLYBDENUM



Nose wheel landing strut piston is inspected with a G-E OX-250. Power of 250,000 volts permits short exposure times without disassembly.

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when G-E x-ray units speed aircraft inspection

X-RAY inspection-without-disassembly is routine preventive maintenance at the St. Paul, Minn., overhaul depot of Northwest Orient Airlines. Records show their two General Electric x-ray units not only save time and money, but also contribute to longer parts service life. Oil cooler radiator overhaul, inspection of nose wheel strut piston . . . examination of prop blades . . . welds — these are typical jobs now assigned to x-ray.

And the widespread use of General Electric x-ray apparatus is not limited to airlines. Thanks to specialized G-E engineering, all industry is able to speed inspections of complete metal structures. Compact x-ray tubeheads can be passed through small opening for radiographic examinations of welds and castings. Aircraft structures, ship hulls, pressure vessels, steam pipes are just a few of the products that are tested nondestructively, at low cost.

Have you considered x-ray for inspection and quality control? Ask your G-E x-ray representative for facts on this complete line of x-ray equipment. Choice of 25 models in every practical voltage range. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Room AS-44

Industry's most versatile x-ray unit, the OX-175, is used to check oil cooler radiator. Cost of x-ray examination: $5.00. Previous mechanical inspection cost $40.00—and required removal of coring, thus shortening life of radiators.

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190 outstanding engineers

For complete details of contents, see your August 15, 1955, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is $4.00 to ASM members, $6.00 to non-members.

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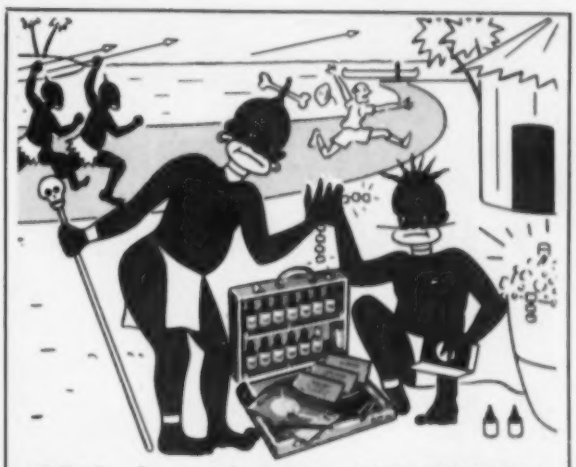

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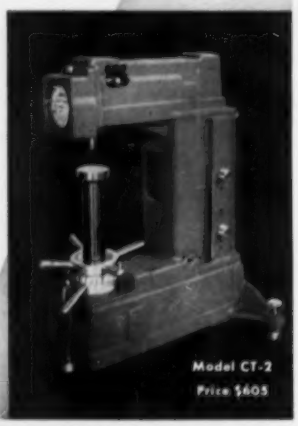

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100 TO 1200 RPM!

Infinitely variable speeds between 100 and 1200 RPM are available for your selection in this completely new line of polishers. They are made in one, two or three unit table and in unmounted units with polishing wheels of 8", 12", or 16" diameters.

The speed variation in the heavy duty gear head motors is controlled by a stepless changing of internal belt pulley diameters.

When the control handle is turned clockwise it actuates a pivotal strut which slides one of the Selecto Discs on the motor shaft toward its companion, thus causing the V-shaped Selecto Belt to climb upwardly on the tapered discs to a larger diameter. Simultaneously the Selecto Belt causes the slidable Selecto Discs on the driven shaft to retract against a spring that permits the belt to assume a smaller diameter, which diminishes in ratio to expansion of the companion diameter.

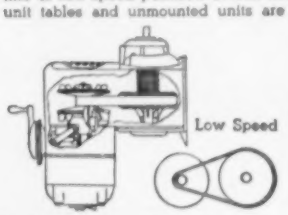
A unique feature of this equipment is the illuminated speed control selector whereby the operating speed of the wheel is shown on an illuminated ground glass disc in the table top above the speed selector control switch (see inset). This is accomplished by means of an ingeniously designed optical system which provides ready and easy observation and precise and immediate adjustment of wheel speeds.

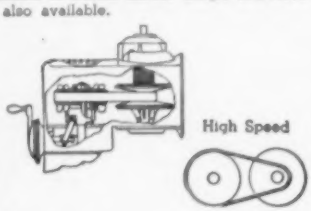
With the AB Selecto Speed Deluxe Polishing Apparatus there is offered a companion wall cabinet with concealed light for illuminating the polishing wheels, and a floor cabinet. Complete assemblies of this type are the answer to many different problems of laboratory layout and installation. The standard Buehler line of two speed polishers is also available in similar tables. Single and three unit tables and unmounted units are also available.

1850-2 AB Selecto Speed Polishing Apparatus with 1513-2 AB Steel Panel and Channels and 1512-2 AB Wall Cabinet

1850-2 AB Selecto Speed Polishing Apparatus

Illuminated Indicator Showing Wheel Speed.





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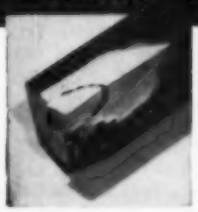

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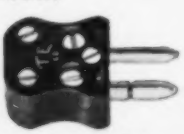

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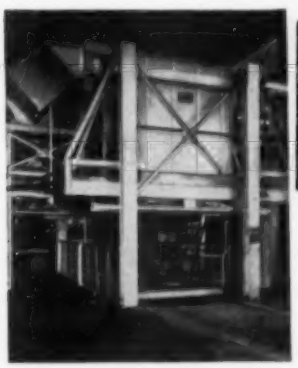

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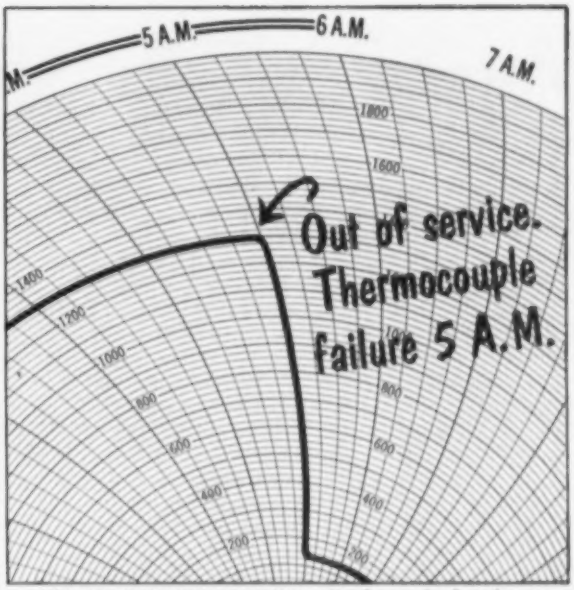

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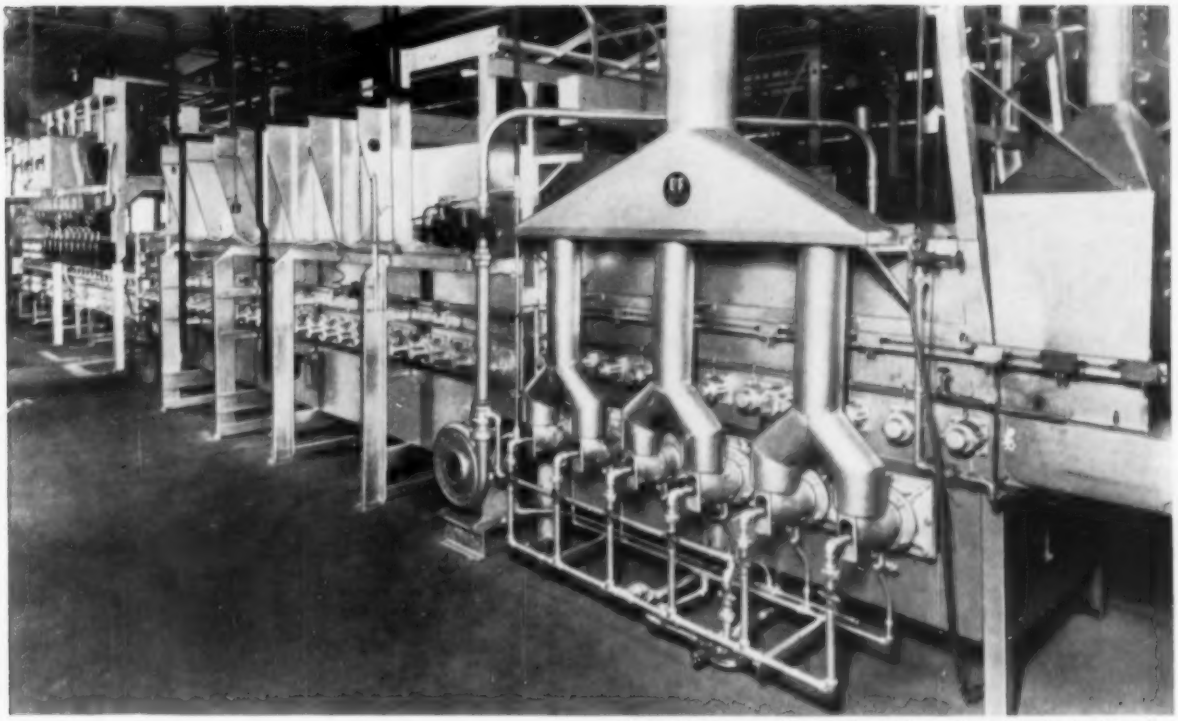

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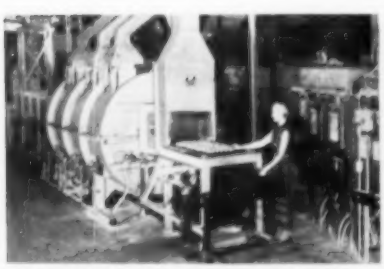

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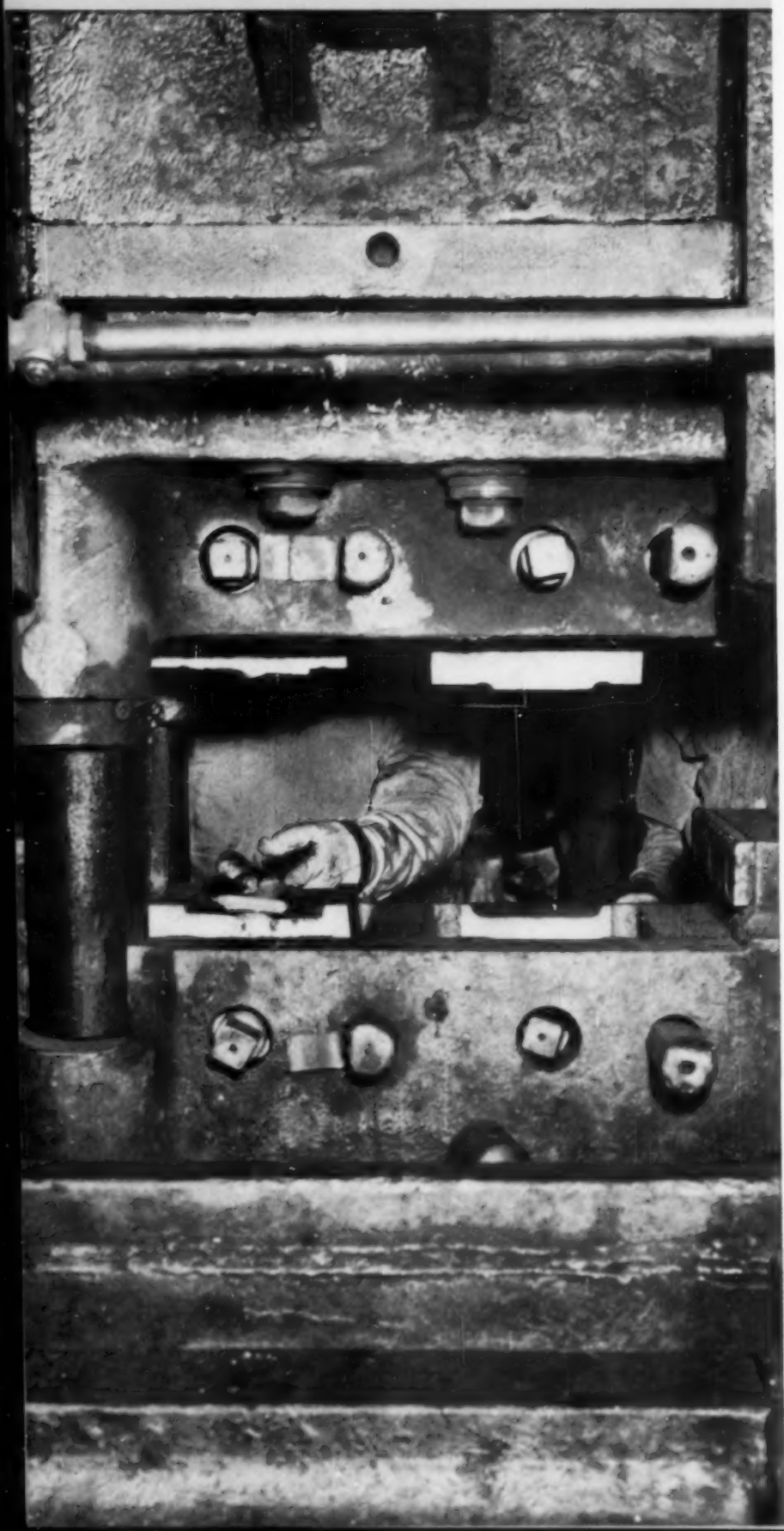

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